metal finishing Journal

PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES

Founded 1950 as the INDUSTRIAL FINISHING JOURNAL

Vol. 6 No. 66 (*New series*) JUNE, 1960

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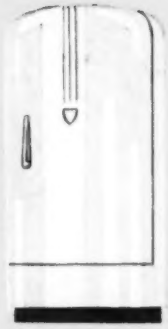

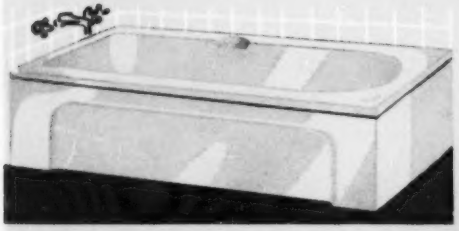

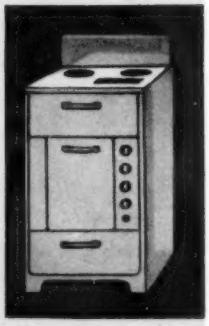

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Photograph by courtesy of Jaguar Cars Ltd.

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A moist white powder readily soluble in water, containing alkaline detergents, hydrocarbon solvents and low foaming surface active agents. A heavy duty soak or spray cleaner for ferrous metals, copper, and magnesium.

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A moist cream coloured powder, readily soluble in water, consisting of alkaline detergents, organic surface active agents, hydrocarbon solvents and rust preventatives. A medium to heavy duty cleaner for ferrous and non-ferrous metals as a spray cleaner

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A dry dust free mixture of buffered alkalis, water softening agents and low foaming wetting agents, a mild, medium duty alkaline cleaner for aluminium, zinc alloy, brass and ferrous alloy base metals, applied by spray or immersion.

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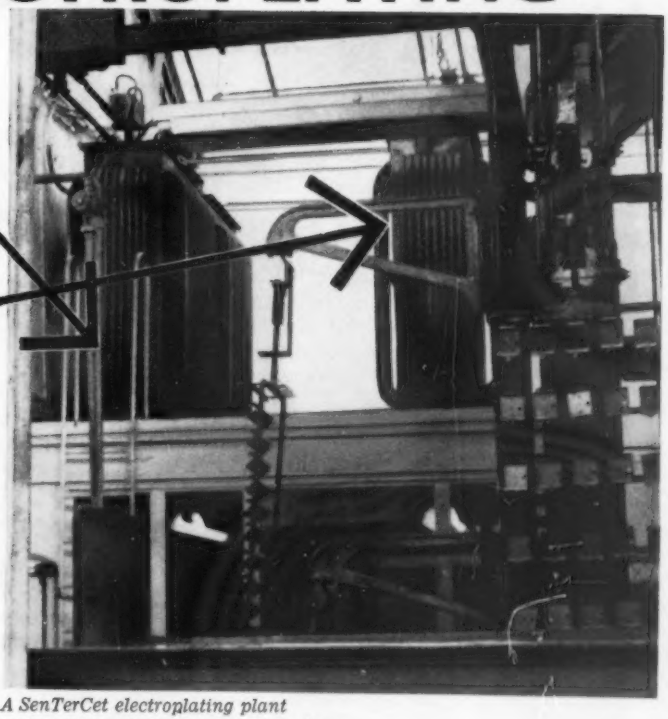

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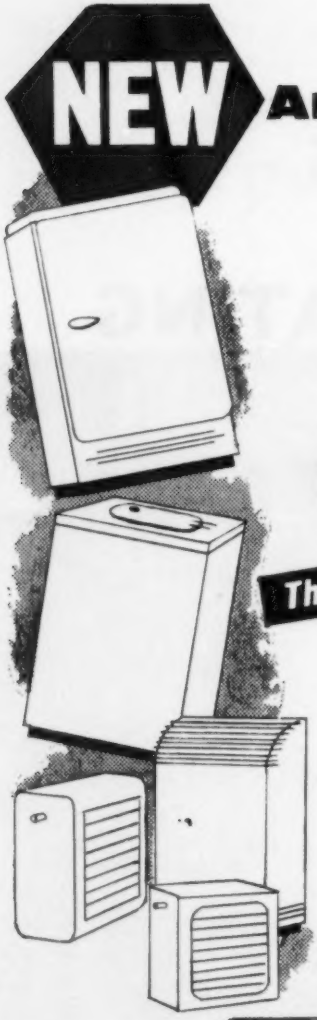

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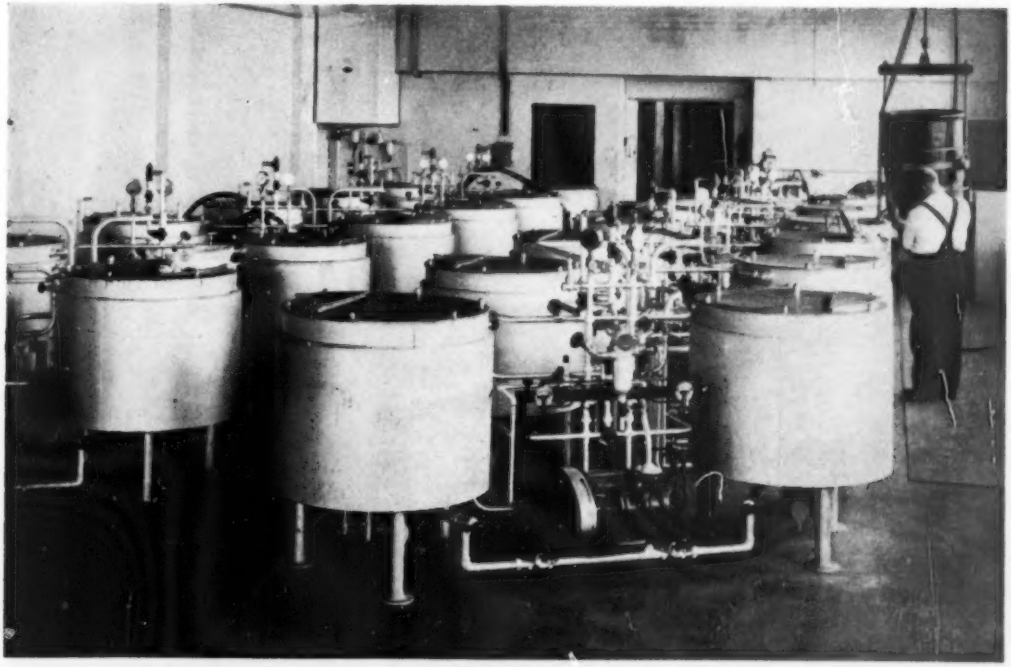

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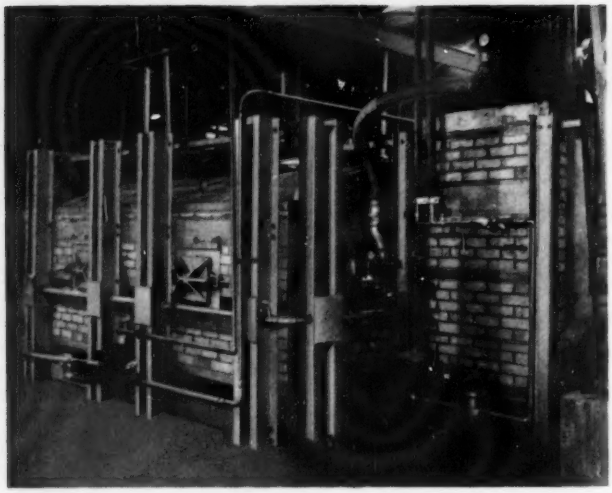

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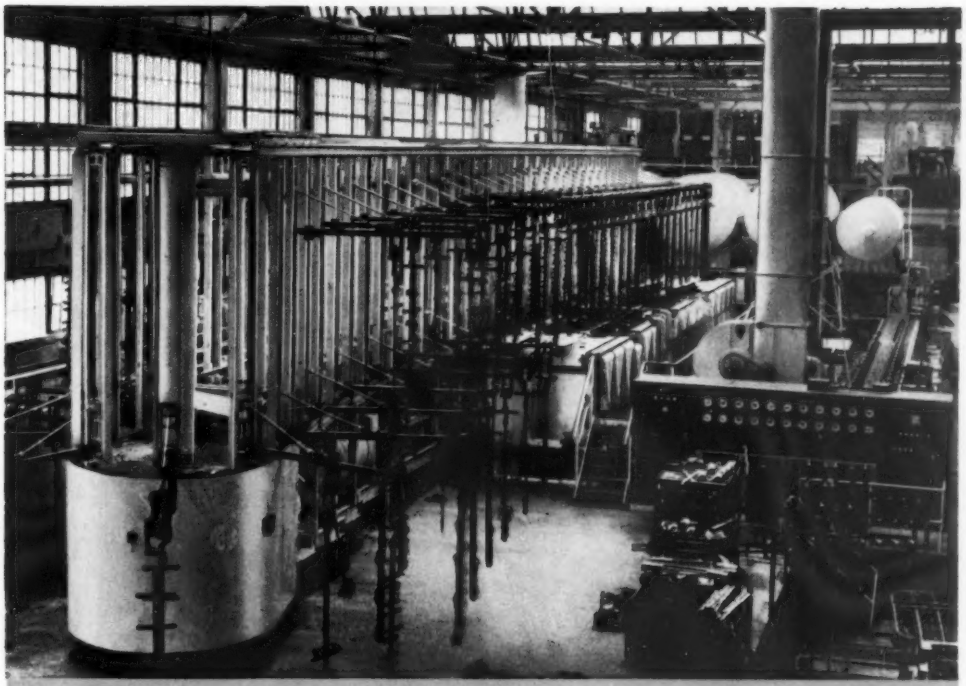

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Fully Automatic Plants catering for all electro-plating and other metal surface treatment processes and ranging from small size machines to large automatic plants with all accessories

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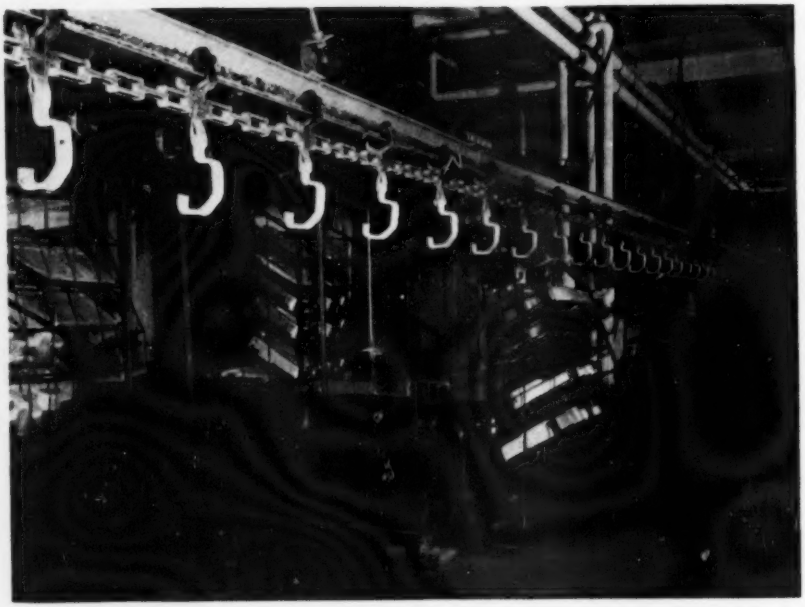

Illustrating the twin line pretreatment plant (the first of its kind in Great Britain) which together with 2 conveyor ovens and ancillary equipment provides a complete installation for the finishing of the world famous Gestetner Duplicators.

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BAKER BRIGHT SILVER PROCESS

- Deposits are hard and highly ductile and provide a mirror bright finish.
- Brighteners completely stable with no deleterious decomposition products.
- Non-critical, economical operation and control.

The special features accomplished by the Baker 'Silva-Brite' Plating process include the following :

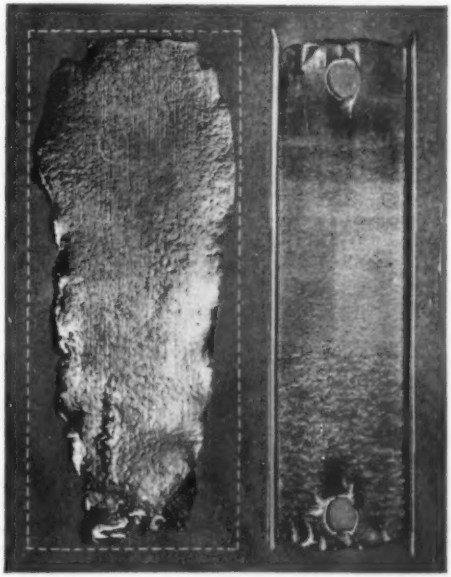
- The clear, water-white solution enables the plater to watch work in the process of being plated.
- The solution possesses excellent throwing power.
- Room temperature operation.

'DOG-BONE' SHAPED SILVER ANODES

The 'Dog-Bone' cross-section ensures uniform dissolution throughout the life of the anode. Anodes of this type compare very favourably against conventional sheet anodes. For instance, when both types of anode have been operated under similar conditions, until only 15 per cent of their original weight remains, the loss of surface area is approximately three times greater for the conventional sheet anode than for the 'Dog-Bone' anode. This even dissolution eliminates anode 'shedding' and gives smoother deposits free from roughness.

'Dog-Bone' is a registered trade mark.

Leaflet giving further information is available on request.



Comparison of conventional and 'Dog-Bone' anodes after identical weight loss illustrating high retention of surface area of the Baker 'Dog-Bone' anode.

ENGELHARD INDUSTRIES, LTD. BAKER PLATINUM DIVISION

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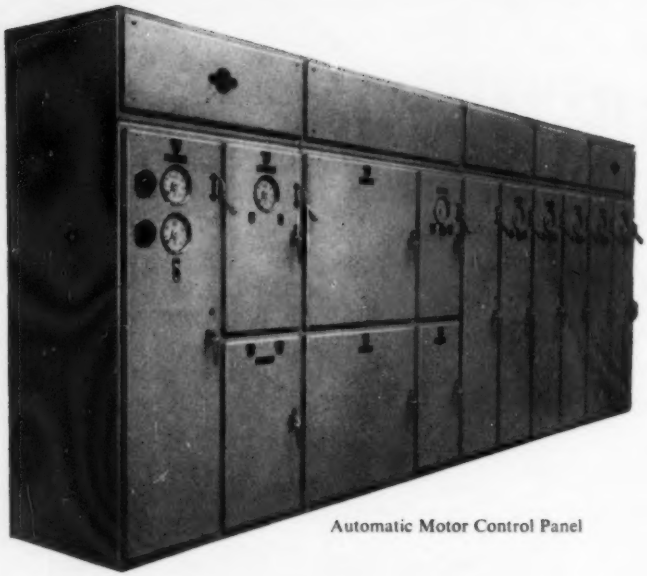


Automatic Motor Control Panel

A FLEXIBLE AUTOMATIC STOVING OVEN

Output doubled and costs halved at Brookhirst Igranic

The names Igranic and Brookhirst have been synonymous with electrical control for three decades and, following the trend towards applied automation in industry, the output of electric motor control equipment from Brookhirst Igranic Ltd. of Bedford continues to increase at an enormous rate. The Company supplies electric motor control panels and cubicles for every industry. Often the control equipment is installed in corrosive environments and the casing must adequately protect the thousands of electrical connections upon which the continuous operation of a factory might depend.

In the Bedford factory the Company was faced with the problem of satisfactorily stoving paint on a number of different control housings of vastly different size and in many different colours. The existing batch oven could only deal with three housings an hour, took nearly three minutes to load and unload, required an average stoving time of three-quarters of an hour and the estimated cost was 1/3d. per housing. But as Mr. Lincoln, the Production Engineer, said, "Before installing the new oven considerable investigation was made into the costs and performance of the available fuels and, largely because of the economics and cleanliness of the combustion products, it was decided to use a direct gas-fired oven."

In conjunction with Edward Curran of Cardiff, the production engineers designed and planned an oven which would meet their requirements and then had it constructed to their specification. Basically these requirements were:—

(*a*) Flexibility of component size, surface area and ultimate finish.

(*b*) Complete safety for the operatives.

(*c*) Automatic control with provision for over-riding manual control for awkward work pieces.

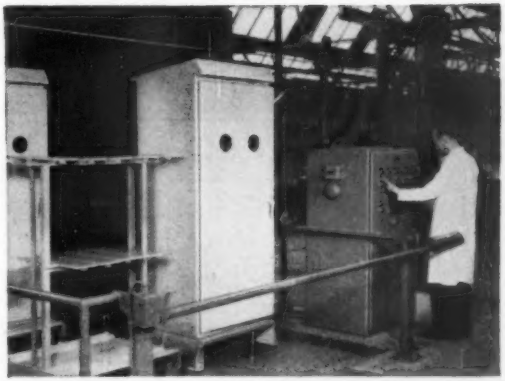
(*d*) Economic fuel consumption.

The oven as ultimately erected is shown in the illustration. Steel components are given a precise chemical treatment to ensure cleanliness of the metal particularly at the welds. From the cleaning plant these components pass to a boothless spraying unit where powerful under-floor exhaust fans extract overspray. Thence they pass to the stoving oven.

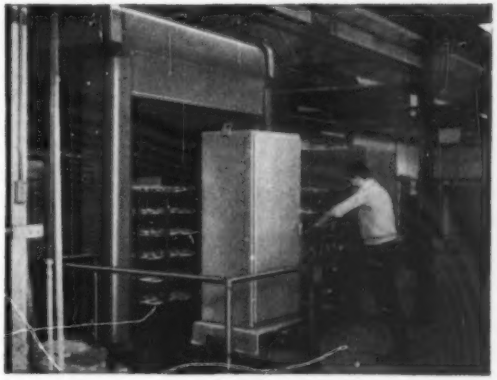
The B H I Production Engineers decided on a fixed time/temperature stoving schedule of 21 minutes at 300°F. Then their paint suppliers delivered primer and finishing coats in a variety of colours which could be fully stoved within this period. As a result, not only did this gas-fired oven offer flexibility in component size but also in component colour.

The sprayed components are brought up to the oven, the bottom of which is formed by a floor conveyor. The safety gate is raised and during this period there is no possibility of movement of the conveyor. The component is loaded on to the conveyor and the gate is closed. Already there are three batches within the oven itself. At the end of seven minutes, the entrance door designed as a roll shutter is lifted. Simultaneously the exit door opens. The conveyor moves forward taking the unit to be stoved into the oven and at the same time removing a unit which has been stoved for 21 minutes from the exit end. The doors again close automatically and this cycle takes place continuously throughout the day. Should a housing which has been removed from the oven not be taken from the conveyor, there would be a danger that at the end of a further seven minutes, another load from the oven would collide with it and when the oven door closed, damage to the doors and the unit would be incurred. Thus each exit load passes across a beam of light focussed upon a photo-electric cell. If the finished unit is not removed within two minutes both a visible and an audible alarm signal are operated.

Sometimes units are so large that they will not conform to the three-space load system adopted for general production work. In such circumstances, the oven can be switched over from automatic to manual operation and used as a normal batch oven. The clock is set for the stoving time required and the doors may be operated singly and the movement of the conveyor controlled manually by switches on the oven control panel which was also designed by the B H I Engineers. Mr. Lincoln then demonstrated what this rigid time/temperature stoving schedule means in practice. "Look at those composite housings, all joined together in a single unit," he said. "When we were on manual control with the old batch oven you often found one unit in the middle of about fifty which was a different colour from the rest—it had to be taken out, the electrical installation removed, the paint stripped off and repainted. The cost and inconvenience were serious to us." He also pointed out that whereas components stoved in the old oven broke down in the salt spray test in five days, now they show only slight signs of breaking after 25 days. He then referred to economics and gave the comparison below of the performance of the old batch oven with the new one.



Checking the timer control panel and showing housing about to enter oven.



Collecting the stoved product from the outlet side.

	Old	*New*
1. Maximum output per hour	3 Housings or their equivalent	18 Housings or their equivalent
2. Maximum hourly gas consumption	900 cu. ft.	3,500 cu. ft.
3. Time for loading and unloading	150 seconds	22 seconds
4. Number of housings loaded each time	1, or its equivalent	2, or their equivalent
5. Average time of stoving cycle	45 minutes	20 minutes
6. Average cost per housing	15d.	4d.

One contribution to the reduction in stoving costs per unit was undoubtedly the careful balancing between the extraction and circulation fans, for, if one notes the pyrometer reading when both doors are open, it is found that there is virtually no drop in temperature. "What is more," said Mr. Lincoln, "the gas is so efficient that you can build up the oven temperature from cold in 6 minutes."

Brookhirst Igranic complimented the Eastern Gas Board upon their collaboration and service during the installation of the oven and its subsequent running in, and this is but one example of the co-operation between the Industrial Officers of the Area Gas Boards and manufacturers. These Industrial Officers from up and down the country meet regularly to exchange views, so that whenever a factory has a heat engineering problem, then by consultation with the Area Gas Board it can take advantage of this pooled knowledge. Industrial Officers, in addition, have the benefit of information received regularly from the Industrial Gas Information Bureau, which keeps in touch with new developments in gas utilization throughout the world.

Scottish Gas Board, Edinburgh.
Northern Gas Board, Newcastle-on-Tyne.
North Western Gas Board, Manchester.
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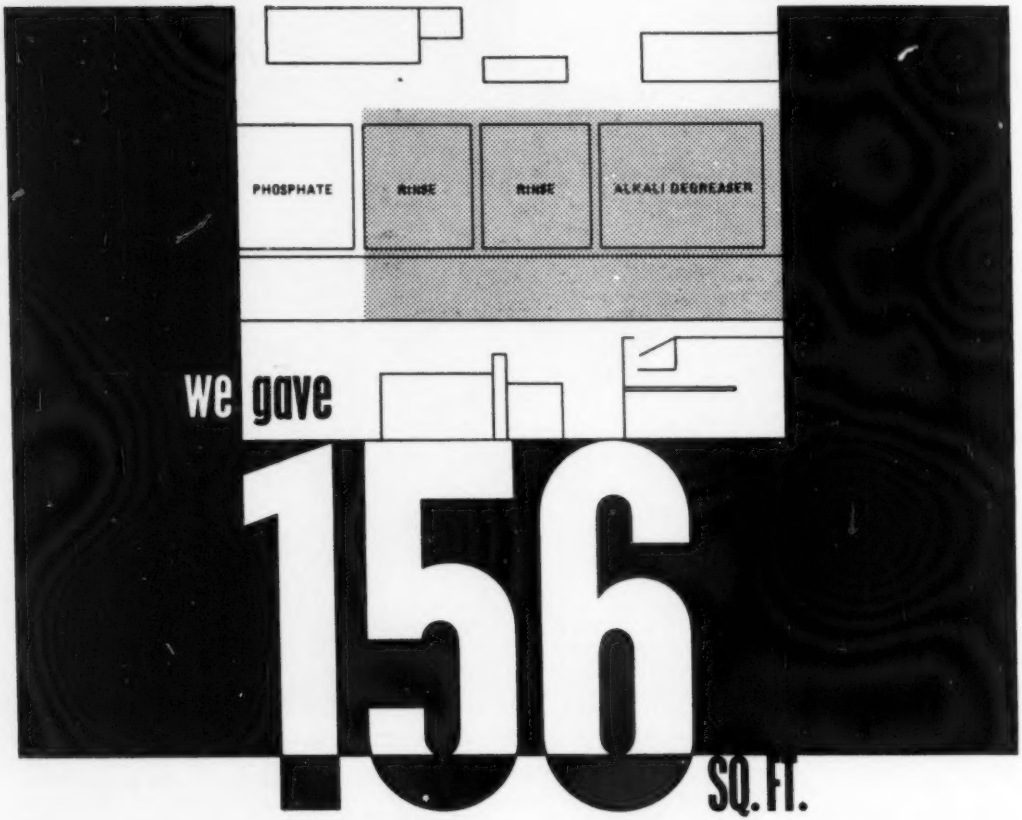
Wales Gas Board, Cardiff.
Eastern Gas Board, Watford.
North Thames Gas Board London, W.8.
South Eastern Gas Board, Croydon.
Southern Gas Board, Southampton.
South Western Gas Board, Bath

The Gas Council, 1 Grosvenor Place, London, S.W.1.



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156 SQ. FT.

to a customer

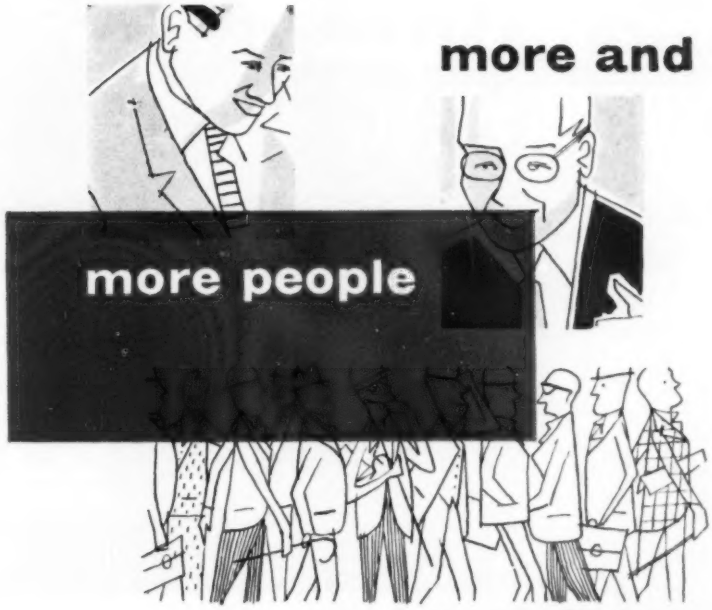
by installing Hellermann metal treatment processes

156 square feet of **extra** floor space ! You can read about the advantages of Hellermann Fospro phosphating solutions in publication BH75A — we would be delighted to discuss with you the **space-saving** features of Hellermann processes.

How much may we give you?

Phosphate Protection Division **Hellermann Limited** Crawley Sussex England

A subsidiary company of Bowthorpe Holdings Ltd



The Metklens range of ferrous and non-ferrous metal cleaning and surface treatment products has been designed to meet the requirements of modern industry. A copy of the Metklens booklet giving details of the varied applications of this range will be sent free on request from Laporte.

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Metal cleaning products for industry by . . .

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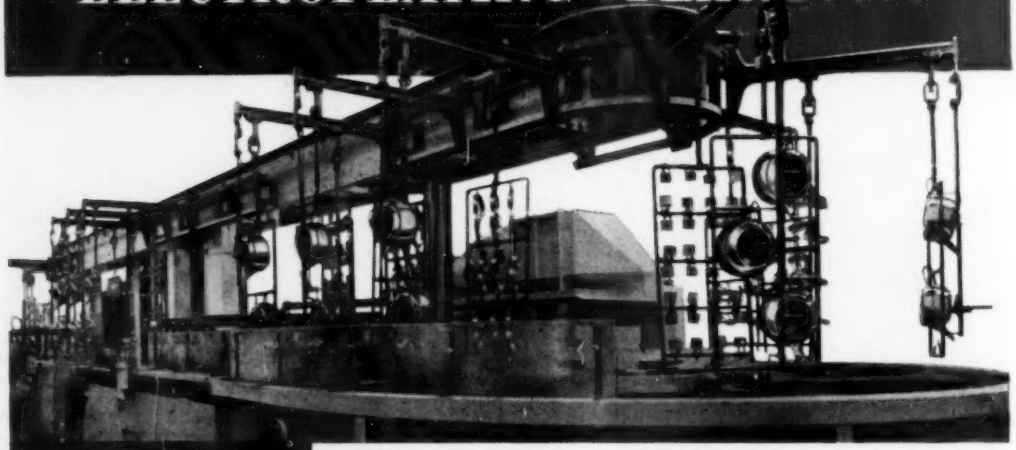
CANNING

Automatic

ELECTROPLATING PLANT....



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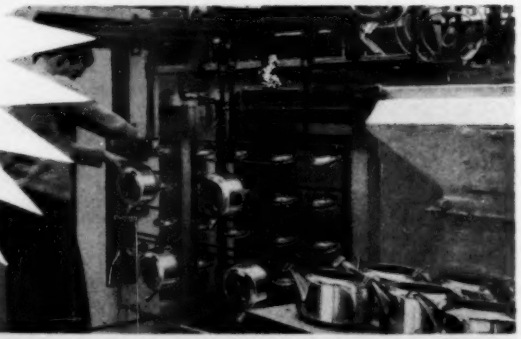
The change-over from manual to automatic plating was made without loss of production.



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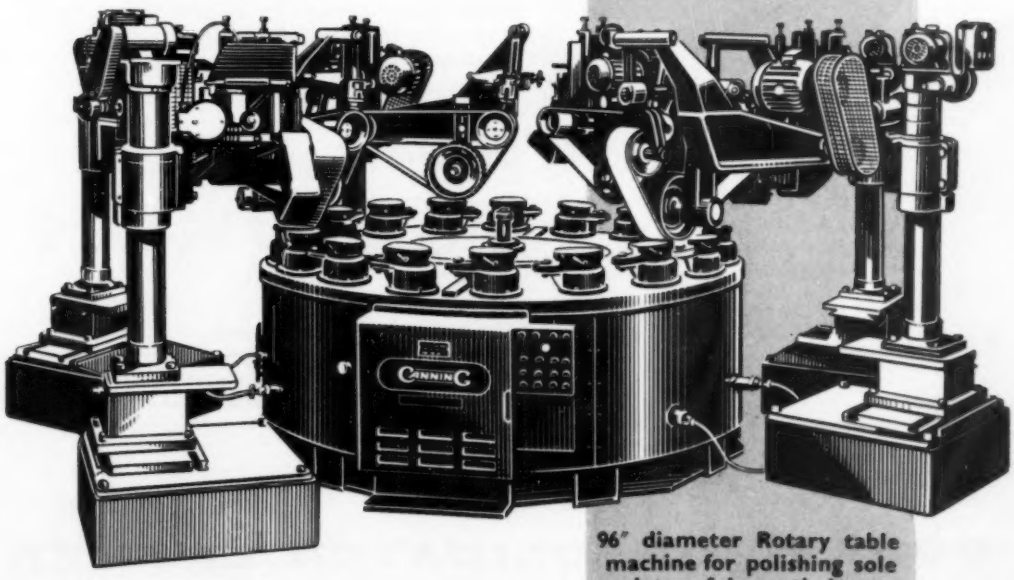

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metal finishing Journal

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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

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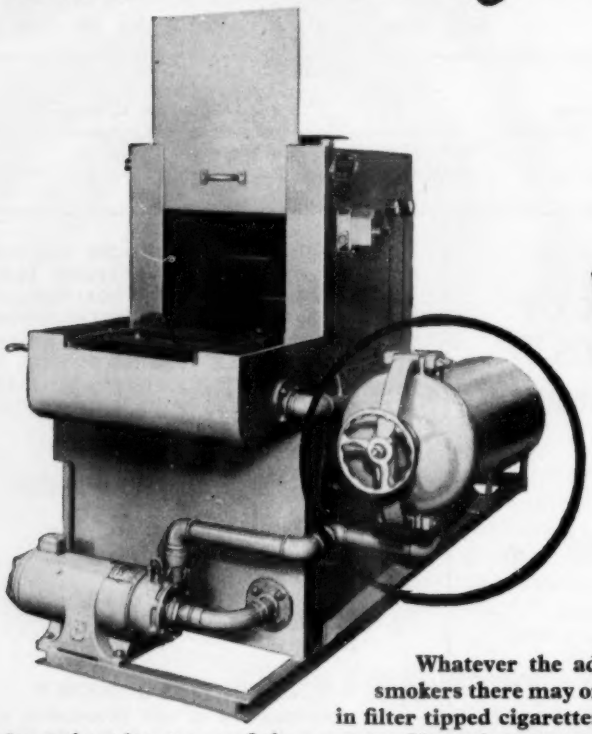
A FILTER TIP
in metal cleaning



Whatever the advantages to smokers there may or may not be in filter tipped cigarettes, there is no question about the advantages of the pressure filters (patent pending) which Dawson Bros. fit to many of their metal cleaning and degreasing machines. These high fidelity filtration units are particularly suitable for handling the very fine swarf prevalent in modern machining methods for aluminium, cast iron and similar metals. The heavy duty, finely woven, nylon fabric bag prevents the recirculation of even the very finest swarf on to the parts being cleaned, and consequently, keeps the jets free from clogging. The bag is easily removed from its perforated drum and another fitted, and, of course, after being washed, it can be used over and over again.

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FACING UP TO IT

THE industrial utilization of metals involves considerable interaction between the metallic surfaces and their environment to such an extent that the surface properties can be of greater significance than the bulk properties of the material from which a component is made. Resistance to wear, to corrosion, and to failure through fatigue are all properties which are a function of surface character, apart from any consideration of appearance or eye appeal which must necessarily be taken into account when a component is to be marketed. Processes for improving appearance and imparting a decorative finish to metal articles are well known and widely used. Methods of protection against corrosion are also familiar and are finding more general application and there has been evidence from the published work of the past few years that the influence of surface finish on fatigue strength has also received a measure of study.

The need to enhance the resistance of a metal surface to wear and abrasion is more specialized and has generally been met by one of two broadly different processes. The deposition of thick coatings of chromium of a high hardness has proved highly successful as a means of providing a wear-resistant surface coupled with excellent resistance to corrosive attack and, particularly where the surface of the chromium has been modified by specialized techniques, good retention of lubricant. Another method of achieving a similar end has been the so called "hard surfacing" or "hard facing" process which involves the deposition of hard metallic alloys, usually containing tungsten and cobalt, by methods which are strongly akin to oxyacetylene or electric-arc welding. Similar processes are also used for the restoration of the original dimensions of worn engineering components—a field in which the electrodeposition of heavy coatings of chromium and nickel has also found application.

It has thus come about that developments in the provision of hard, wear-resistant surfaces and in the reclamation of worn components have taken place in two widely differing technologies, electrodeposition and welding, both of which are effectively served by technical institutes.

There has however, lately appeared some confusion in the degree of clarity of separation of these two unrelated fields. This has arisen as a result of the fact that the metal-spraying process is being increasingly widely used in both contexts, that is to impart mechanical and dimensional properties in a manner akin to the hard-surfacing welding process and to afford protection against corrosion, which is undoubtedly a surface-finishing process in many ways akin to hot dipping. Papers and discussions on metal spraying subjects have been included in the programmes of both the Institute of Metal Finishing and the Institute of Welding, in addition to which specialized meetings have been convened by bodies representing metal-spraying interests. These two differing applications of the metal-spraying process, although involving the use of identical equipment, are so divergent in concept, uses and requirements that there can be few grounds for bringing them both under the umbrella of a single technology. Furthermore, the question is yet more vexed by the introduction of plastic coatings, sometimes sprayed but now more commonly dipped and sintered. Metal spraying as a finishing process undoubtedly has a very important part to play in the future, particularly in the section of large structures such as bridges, and it would be unfortunate if it failed to get the full value of support that an Institute can give because of failure to resolve a technological demarkation issue.

Talking Points

by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

WHAT'S THEIR LINE ?

THE prominent advertisements for technical staff which now take up so much space in the more select Sunday newspapers become consistently more esoteric. So much so, that one wonders if those to whom the advertisements are expected to appeal ever recognize themselves (or their potential selves) in the mystifying descriptions they contain.

What can anyone make of an opening offered by a razor manufacturing firm for a Creative Visualizer ? Are there any courses in creative visualizing in the universities or technical colleges, and is there yet an Institute of Creative Visualizers ?

Another strange demand, this time by an accounting machine manufacturer is for Logical Designers. I have no idea what such designers do (and without being facetious) neither have I ever met one, but I presume they exist.

Sometimes, even when the title is simple, the function is surprising. For example, a famous electronics firm advertises for an Engineer, whose job it will be to " ensure that equipment design is compatible with customer's requirements." This makes one wonder whether the Managing Director found one day that customers purchasing *p*H meters were constantly ringing up to complain that the meters gave them the temperature of their solutions instead of the *p*H, whereupon the edict went forth that an engineer should be appointed at once to see that the equipment and the customer were mutually compatible — before the latter violently ejected the former. It does seem that the staff selection specialists (like specialists of every type) are rapidly evolving a jargon of their own. Let us hope that those whom they are seeking are familiar with it !

MORE CORROSION WANTED

LAST November, it was suggested in this column that the elimination of the vast " losses " due to the corrosion of iron and steel would not be the unmixed blessing that some statisticians make out. This view has recently found support from a surprising source — none other than Sir Donald Anderson, Chairman of P. & O. Referring to the crisis in world shipping resulting from surplus capacity, Sir Donald said in a recent interview that a scrapping scheme was really impracticable although he did see a solution : " Oxidization of iron is the answer " he said. " It can, after all, cost up to £100,000 to put a ship back into service once it has started to rust in port. Unfortunately, this is a longer process by far than a world wide scheme of scrapping old and surplus tonnage."

This offers the prospect of a novel approach to the study of corrosion which may appeal to the newly formed Corrosion Science Society, for example. Here is a vast industry which is in serious trouble — trouble which could be mitigated if only some means could be found of accelerating the rusting of ships in port. There is no doubt that some research work would lead to a method of accelerating corrosion which could be made to pay handsome dividends. Such an investigation would, in any event, have the outstanding characteristic of being a complete innovation.

AS IT SHOULD BE

" THE treble-armour of resin enamel paintwork endures all weathers and is the only garage a VW needs." So reads a recent advertisement, and this in fact is no more than any car owner has a right to expect in this day and age — yet few manufacturers are prepared to " stick their necks out " as far as this.

Car finishes should stand up to all weathers without having to be dried, polished, waxed and generally cossetted. After all, it is not so many years since car manufacturers expected vehicles to be kept in a heated garage overnight in the winter to ensure that they would start in the morning, but even those days are over.

ENCYCLOPEDIC KNOWLEDGE

WHAT sort of people write encyclopedias and where do they get their facts from ? Users of a modern one first published in 1955 under the imprint of a famous University Press, will be interested to learn that " electroplating is carried out in baths which may be as large as 6 ft. long by 3 ft. wide by 3 ft. deep. These baths are often wooden with a lead lining to protect the wood from the acid or of concrete protected by asphalt." Anyone faced with the problems of dealing with large articles will find it useful to be informed that these are " hung from wooden beams " for plating. The supply of current is from " special generators which provide electric currents of up to 2,000 amperes at a voltage of 6 volts." Perhaps the 1970 edition may mention rectifiers !

THE METAL FINISHING CONFERENCE

SCARBOROUGH, APRIL 27 to 29, 1960

A Report of the Annual Conference of the INSTITUTE OF METAL FINISHING

(*Continued from page* 199, *May*, 1960)

ABSTRACT NO. 5

THE GROWTH HABIT OF ELECTRODEPOSITED COPPER

by G. C. Storey and S. C. Barnes**

SEVERAL papers have reported that under deposition conditions which favour base deposit crystal continuity the surface topography of the deposit may be determined by, and related quite simply to, the atomic configuration of the initial cathode surface. The materials used to obtain this result were cube-texture copper strip or copper single crystals as cathode material; cathodes were electropolished.

The present paper extends the work on the subject to deposition conditions more related to those in industry; *e.g.* factors studied include deposition on random polycrystalline copper strips; and effect of variations in the finish of the initial cathode surface on deposit structure. The electrolytes used were 0.5 M Analar copper sulphate solutions with and without a subsidiary purification treatment. The work also included an examination of deposits from cyanide solutions.

For studying deposition onto electropolished polycrystalline cathodes from untreated acid sulphate solutions the material was heavily cold rolled OFHC copper subsequently annealed in vacuo at 1010°C. for 3 days, producing large grains with a limited range of orientations, which, in the case of the larger grains, were determined by the Laue technique. Electropolishing was effected after a normal metallographic preparation, the deposit being examined by optical microscopy, X-ray diffraction, optical goniometry and sectioning. The influence of microtopographic variations on growth habit was also investigated.

A sulphate solution treated by carbon was also used for deposition.

Deposition was also effected onto mechanically polished cathodes prepared on large-grained OFHC copper by a variety of means, and also onto cube-textured cathodes using a cyanide solution.

* Joseph Lucas Ltd.

As a result of the experiments it has been possible to show that by plating from acidified copper sulphate solutions under base reproduction conditions, the structures formed on the individual grains of a polycrystalline cathode are identical to those formed on single-crystal cathodes of the same orientations. The variation of surface structure with cathode orientation in treated Analar solutions differs from that obtained in ordinary Analar solutions, particularly on surfaces inclined at more than 20 deg. to a (100) plane. However, in both types of solution there is a variation in the thickness of the deposit formed on a polycrystalline cathode. This can be explained in terms of electrochemical anisotropy.

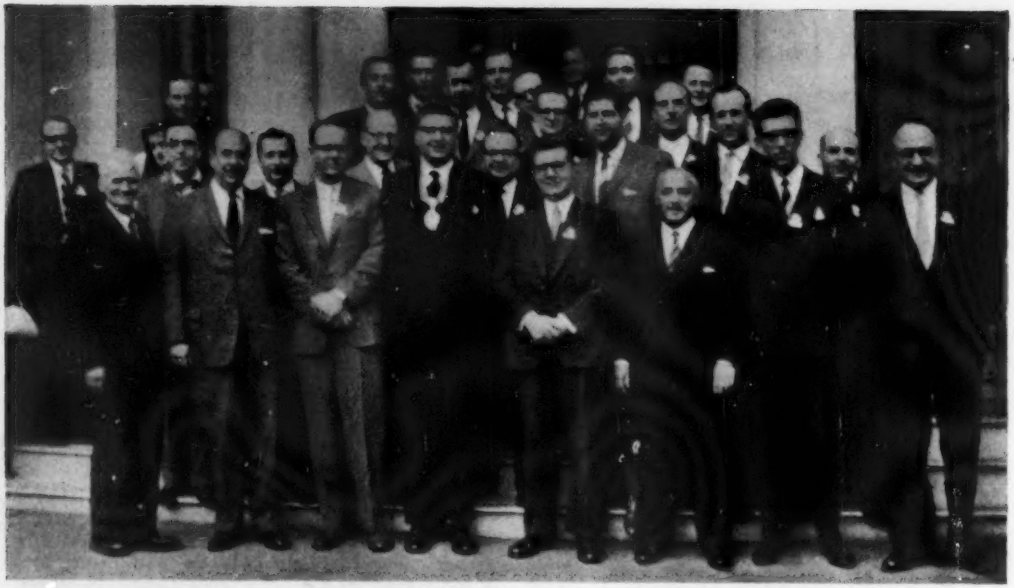
The process of growth occurs in a similar manner on electropolished and etched cathodes. Bases that are mechanically polished give polycrystalline textured deposits although some base influence can be detected through thick deposits.

At a sufficiently low current density, base reproduction can occur in deposits formed from a cyanide solution similar in composition to that used industrially. The formation of polycrystalline material can, however, occur after long plating times, but it is sensitive to the orientation of the grains of the basis metal.

As in acidified copper sulphate solutions the growth habit of the deposit is very sensitive to the cathode orientation and on many surface planes large facets form which coarsen with plating time. Furthermore, the deposition process is strongly influenced by impurities in the cathode surface.

DISCUSSION

DR. L. SHREIR (Battersea College of Technology), after complimenting the authors on an excellent and very comprehensive paper, said that the two types of solution used, the copper sulphate unpurified using Analar copper sulphate and the purified solution using a carbon purification technique, gave different types of crystal structure. This was of particular interest from many points of view. Some years ago he had had some dealings with the acid copper sulphate solution and found



The President and some members of the Council are posed here with a group of the overseas delegates to the Conference representative of twelve countries

that it was by no means simple and was very susceptible to trace impurities from the points of view of crystal structure and overpotential. The measurements with which he had been concerned were essentially overpotential measurements and he had not looked at the deposits in the way he should have done ; the paper showed him the sort of work that he ought to have done some years ago. What he had found was that an acid copper sulphate solution was extremely unstable, and, depending on the method of preparation, the atmospheric conditions and the time of the year, vastly different results could be obtained. The literature contained many similar observations. As long ago as 1913 some workers found that they were obtaining incorrect results and that the reason was that the filter paper enclosing the anode had introduced impurities into the solution.

In considering copper it was interesting to find that many papers showing the influence of impurities had been written by people familiar to the Institute of Metal Finishing and had been published in the Journal of the Electrodepositors' Society. For example, *Ollard* in 1929 found that a specially-prepared solution gave deposits of copper having larger crystals than were obtained from a solution which had been in use for some time. *Hothersall* in 1937 found that different hardness values were obtained from copper sulphate solutions depending on the method of preparation and treatment of the solution. Contamination by filter paper and rubber tubing gave faulty crystal deposits.

Effect of Impurities on Nature of Deposit

So far as the work which was being done at Battersea was concerned, the main point which he wished to make was that an impurity such as H_2S in the atmosphere might have a pronounced influence on the crystal nature of the deposit and on the overpotential associated with that deposit. There were one or two questions, therefore, which he wished to ask relative to reproducibility. First, did the authors consider that their type of purification was adequate for the type of work which they had carried out? The treatment given at Battersea was to boil the solution with hydrogen peroxide and then boil it with carbon and then pre-electrolyze before carrying out any polarization studies. Possibly the authors would consider that type of treatment more satisfactory than the one which consisted of boiling with carbon. There were several other points which he could mention, but they would be dealt with by his colleague Mr. Prall, who would speak later.

MR. R. A. F. HAMMOND (Armament Research and Development Establishment, War Office), observed that much of what the authors had described was nothing new. It had been known for a very long time that preferential growth occurs on certain orientation facets of a crystal, and ac a cost of

The greater part of the organizational work involved in the Conference was performed by the Social Sub-Committee of the Conference Committee of the Insitute. The Chairman of the Sub-Committee Mr. J. Pigott is seen here (centre) with some of the members of the Sub-Committee, including A. A. Evans, J. H. Woods, C. E. Proctor, R. T. F. McManus, G. C. and R. A. Nicol.

reduced growth on other orientations. What the authors had done which was very valuable was first of all to demonstrate the different rates of growth on selected orientations, and they had shown that the (100) was the favoured and the (111) the least favoured plane for crystal growth. Most important of all, they had been able to establish the correlation between the rate of deposition on a particular crystal surface and the overpotential of copper deposition on a surface of that orientation.

On reading this he had been reminded of the work which *Hothersall* had done many years ago on electrodeposited copper, in which he had deposited various thicknesses of bright nickel on two successive layers of copper from an acid copper solution and found that up to a certain limiting thickness the grain boundaries of the succeeding copper deposit continued one into the other, and *Hothersall* thought that the orientation also continued provided the thickness of nickel did not exceed a certain critical value.

Plating Copper Single Crystal with Nickel

Mr. Hammond thought that this might provide a useful means of exploring further the bases for the theory of the present authors that the differential rate of growth was determined by the different overpotentials on different surfaces. For example, what would be expected to happen if a single crystal of copper was plated with a thin coating of nickel? Would not it be very interesting to know whether or not on such a single crystal they obtained different rates of growth on different orientations on top of a thin nickel starting layer? Second, what would happen if a polycrystalline substrate of the type which they had been using was very thinly plated with a bright nickel? Would it then be possible to observe the differential rates of growth on adjacent crystals? If the answers to those questions were known, it would provide more evidence on which their theory could be based.

He had been interested by what Dr. Shrier had said about the purity of the solution, and especially since the authors obtained significant differences in structure, apparently, from unpurified Analar solution as compared with the so-called purified Analar solution. He wondered whether the purified solution had not been in fact rather less pure than the unpurified one, because they had found that certain structural features were very similar to the same structures in the untreated solution but a whole order of magnitude smaller. He wondered whether the authors had not introduced the impurity. In that connexion also he had been surprised to find that they used refluxing with hydrochloric acid as their purification method, because electrodepositors had known for many years that a mere trace of chloride in sulphate solution gave rise to large single crystal needle growths of copper and refluxing with hydrochloric acid seemed a suspect procedure for this purpose.

Finally, the authors referred to work on deposits from cyanide solutions in which they had attempted to determine the effect of current density on the relationship between the base metal structure and the deposit. In that series of experiments a uniform time of 1 hr. had been used with a very wide range of current densities, so that even if it was assumed that the cathode efficiency was constant irrespective of current density, which was a large assumption, one would know that there was a very big thickness variation between the different deposits which they had examined. It was not surprising, therefore, that it was possible to observe evidence of base metal influence on the thinner examples but not on the thicker ones.

Dr. P. Baeyens (N. V. Philips), H. Silman (Electro Chemical Engineering Co. Ltd.), and R. Pinner (Consultant)

Deliberately Adding Trace Impurities

MR. J. K. PRALL (Battersea College of Technology) showed two slides illustrating the effects of deliberately adding trace impurities. In the first, with a polycrystalline base, the addition of such a widely varying range of substances as H_2S, ferric oxide formaldehyde and so on all appeared preferential to adsorb on to certain faces. According to the authors the (100) face was more resistant to adsorption. The platelets which were shown appeared at a higher magnification in the second slide, which also showed the start of new growth. At the moment they were studying in more detail a wide range of impurities and trying to find a common factor amongst them all.

His second point concerned the purity of the solution. According to other workers the (111) face gave more active growth than the (100) face, which seemed to contradict the present authors. Also, recent work on copper single crystals showed that the (100) and (111) faces were about 30 per cent higher than were given by the present authors. He did not know whether that was an indication of slight impurity or due to the variation of the experiment.

Last, it would be interesting to know what had happened to the work which had been going on in Birmingham on spiral growth. His third slide showed the sort of growth which he had obtained and which was believed to be a spiral growth. On all the other examples of spiral growth no indication had been seen of origins or source and it would be most interesting to know whether any more work was being done in that connection. It was of importance, because these spirals cropped up in the insufficiently purified copper sulphite solutions with and without added sulphuric acid and also on the deliberate addition of certain agents such as formaldehyde.

A SPEAKER referred to Fig. 6b of the paper which showed the structure of the base metal which had not been etched before plating, and this seemed rather surprising bearing in mind that some specimens had been hand polished with alumina which would give a Beilby layer. It was surprising that the orientation of the base metal had gone through this Beilby layer.

In the first paragraph on page 19 of the paper the authors said " It appears that insufficient growth had occurred to develop plane growth facets." Was that because there were no grains of (100) orientation available, as shown in Fig. 7b?

Authors' Reply

DR. S. C. BARNES, in reply, said that the authors were in complete agreement with Dr. Shrier's observations on the effects of impurities and purification treatments given to copper sulphate solutions. In a search of the literature on this phenomenon it had been found that people working in this system as far back as the nineteenth century had come across variations in the copper dissolved in copper sulphate solutions and in the deposits obtained from them which could only have as their explanation the presence of contaminants. Recently

Dr. Pick and himself had presented papers on the continent and they had come across one explanation for the peculiarities in the system copper-copper sulphate of which they had never heard before, namely that the non-reproducibility in the system could be explained by sunspot activity. That was a novel explanation which as yet they had not had an opportunity to follow up.

In that connexion, some of the observations of *Prall* on the effects of addition agents were interesting. The authors had studied the effects of a dozen or more different addition agents to the morphology of single-crystal deposits, deposits obtained under the particular electrolysis conditions which favoured optic-axial growth, and they had found that concentrations of certain constituents such as Mr. Prall had mentioned, such as H_2S, with any compounds containing divalent sulphur and such as thiourea, could change the morphology with concentrations as low as 10^{-9} and 5×10^{-10}. When the concentration was slightly above this but still very small, say 10^{-7}, the habit of the deposit was completely changed. At the moment he was talking about deposits grown on single crystals near the (100) plane. Dr. Storey had made some observations in relation to the work with treated and untreated solutions. It appeared that the (100) surface was particularly stable against the action of addition agents and impurities. When the authors had deliberately contaminated their carbon-treated solutions they had found that 10^{-7} and 10^{-6} mols of these thio compounds produced remarkable changes. At a current density at which it would expect a plate to be deposited the growth was in the form of small pyramids with flat sides which were now (111), which would seem to indicate that growth had been inhibited more on the (111) surface than on the (100). Whether that was the true explanation or whether adsorption was more or less general over the whole surface and it was just a peculiarity of the atomic structure of the metal he would not like to say.

He thought that the range of overvoltage observed could qualitatively account for the thickness variations with polycrystalline material. That was satisfactory from their point of view, but there was still no real explanation of why the metal itself should be anisotropic in its electrochemical behaviour. The authors would like to do more work on the basis of the electrochemistry of the processes and find out whether the actual kinetics of the processes varied with the crystallographic orientation, and how addition agents could affect those kinetics. The techniques used so far however, were not amenable to making studies of that kind and it would be necessary to reorganize the investigation and use some of the more modern electrochemical techniques.

Mr. Hammond referred to the purification of the solution by the carbon treatment. The authors, however, had been very careful not to call the treated solution a carbon-purified solution. It had been their intention to call it a carbon-treated solution because they were not themselves certain whether it was in fact in a more pure condition after this treatment. It was realized that impurities introduced by the treatment could have an effect on the properties.

The development of this work to study the growth of one metal on another was one of the fields which it was hoped to develop in the future. It was quite a large field, and must be dealt with before they could go on to such a subject as plating bright nickel on to polycrystals in which they knew the orientation of individual grains to study thickness variations and so on. They hoped to do work on those lines. It would mean studying the growth of nickel from simple electrolytes and understanding how this occurred, more or less in the way which Dr. Storey had described, and then seeing the effect of addition agents.

The treatment given to the carbon had involved the extraction of a tarry matter from the carbon, and this had involved continuous extraction for a period of 4 to 7 weeks. The system had then been leached continuously with distilled water until the actual extract in the receiving vessel had been free from any trace of chloride reaction. That had taken a further 3 to 4 weeks, so that the length of time which it had taken to get the carbon into the requisite state of purity had been anything from 7 to 10 weeks. The authors believed that their solutions were free from chloride ions.

The variation of surface topography of deposits from cyanide solutions and the effect of current density on these variations was a topic which they had not studied in very great detail. The point made by Mr. Hammond that at low current density the deposit could very well be optic-axial was of interest. The authors had observed optic-axial growth only at low current densities. That was very important, because they had observed that in the acid sulphate system at high current densities, of the order of 25 to 40 ma. per sq. cm. in thick deposits the surface was polycrystalline but in a cross-section the initial deposit was optic-axial, which illustrated that when plating at a constant current density, although the initial growth might be optic-axial some other process took over from optic-axial growth and the deposit became polycrystalline.

That was, as he had said, quite an important point, because it might have a bearing on the stresses in deposits. It was well known that the strength varied with the thickness of the deposit, and this might be one of the reasons why that was observed. Their own voltage measurements had been made under really simple conditions. They

S. A. Watson (Mond Nickel Co. Ltd.); G. B. Burton, (B.N.F. M.R.A.); G. J. Gilbey, I. MacLeod and C. B. Brown Metals and Methods Ltd.)

had not been hoping to get any kinetic information about the process from those measurements, and so they had not taken elaborate steps to ensure that they were getting true measurements of overvoltage. That might be a reason why the results of P. R. Kelly were in disagreement with theirs.

With regard to spiral growth, in Birmingham they were interested in it but had not undertaken any special investigations into this particular mechanism of growth. All their observations on the growth process had been concerned with growth under such conditions that spirals were not normally observed. In two cases where there had been publication in various journals, one being the Transactions of the Institute, it was a question of casual observations made under conditions removed from those in which they had usually studied the process and he did not think that the Birmingham team as a whole had anything useful to contribute with regard to spiral growth and its contribution to the overall growth of electrodeposits in general.

ABSTRACT NO. 6

THE THROWING POWER OF NICKEL AND OTHER PLATING SOLUTIONS

*by S. A. Watson.**

IN this paper a method for measuring throwing power, using a Hull cell is described. The cell may be regarded as half a symmetrical recess, set at a standard distance from the anode. It is familiar to the practical plater and permits the assessment of throwing power and brightness on the same sample.

Several formulae have been proposed for expressing throwing power measurements in terms of the metal distribution ratio and the primary current ratio. The most widely used is the Field formula, and it has been adopted by the British Standards Institution, and gives percentage throwing power, T in the following manner :

$$T - 100 (P - M) / (P + M - 2)$$

Results using this method appear favourable, with the general trends being independent of the primary current ratios selected, and with good reproducibility.

One objective of the investigation was to explore the possibility of effecting some improvement in the throwing power of nickel plating solutions. It is known that high throwing power is favoured by a decrease in efficiency of deposition as the current density is raised, by high conductivity of the solution and by a steeply sloping polarization curve.

The efficiency of Watt's solution, on which many proprietary bright nickel solutions are based, falls increasingly rapidly as current density is progressively lowered, and this effect, partially nullifies its favourable polarization characteristics, resulting in low throwing power. Most of the improvement possible in this direction has already been obtained with the all-chloride solution and efficiency does not appear to be a promising line for further work.

Improvements in polarization characteristics appears to be the most promising method for increasing throwing power and measurements were made on the following solutions:

* Mond Nickel Co., Ltd.

Dr. H. J. Brinkmann (Erich Kiesow G.m.b.H., Germany), in conversation with Mrs. and Mr. M. L. Alkan (M. L. Alkan Ltd.)

1. Salts of alkali or alkaline-earth metal, to modify the ionization of the nickel salts.
2. Amines or fluoride ions, to complex the nickel.
3. Organic substances known to affect cathode potential.
4. Anions other than chloride or sulphate.

A solution having most of the nickel sulphate replaced by sodium sulphate, exhibited fairly good throwing power.

Attempts to improve throwing power by complexing the nickel ions and increasing the slope of the polarization curve were unsuccessful. High values of throwing power from fluoride solutions were entirely due to inefficient deposition at high current densities, and the solutions were unstable.

Citrates, known to be complexing agents, showed no improvements over the fluoborate or the all-chloride type. Ammonia, though volatile, has the attraction of low cost, but the throwing power of the ammoniacal electrolyte proved to be only marginally better than that of the Watts solution, probably due to the weakness of the complex.

The effects of organic addition agents on the throwing power of Watts solution varied considerably in relation to the concentration of the addition agent. The presence of coumarin resulted in the throwing power becoming negative. These effects are explicable in terms of changes in cathode potential produced by the respective substances.

The greater the difference between the cathode potentials, which correspond to the two primary current densities used to measure the throwing power, the greater, under practical conditions, is the diversion of current from the high to the lower current density region. Polarization curves showed that in Watts solution saccharin is almost without effect on cathode potential and more recently, to have no effect on throwing power.

From the polarization curves for Watts solution containing thiourea and coumarin, it is possible to measure, for various concentrations of addition agent, the difference in potential corresponding to the primary current densities.

As thiourea is added to Watts solution, the potential difference rises, then falls and finally rises again, the throwing power behaving in a corresponding manner. A low concentration of coumarin sharply reduces the potential difference, but further additions cause a progressive rise.

It has been shown that levelling power at a fixed current density is given by :

$$K.C. \frac{\delta E}{\delta C} \cdot \frac{\delta J}{\delta E}$$

where C is the bulk concentration of addition agent, E is cathode potential, J is current density, and K is a constant. Good throwing power is favoured by high values of $\frac{\delta E}{\delta J}$, and it is clear that a concentration of addition agent producing high levelling power will generally give low throwing power. Good levelling and high throwing power will be favoured at the same concentration of addition agent if $\frac{\delta E}{\delta J}$ is high and $\frac{\delta E}{\delta C}$ is relatively much higher, that is, if a solution containing a given concentration of addition agent is to have a high degree of levelling and high throwing power, the slope of the curve showing potential against concentration of addition agent must be sufficiently steep to more than compensate for the steep polarization curve.

Variation of levelling power and throwing power as a function of concentration of addition agent, may be such that, for a given plating time the most uniform deposit will be produced by using two solutions containing different concentrations of addition. Alternatively, solutions containing different addition agents might be needed, to be used in succession.

In the work with organic addition agents Watts solution was used as the basis because polarization data on the effects of such additions were already available. There appears to be no reason to suppose that similar additions will fail to improve the throwing power of the high-speed, all-chloride and other nickel plating solutions which initially have better throwing power than the Watts solution.

DISCUSSION

MR. P. A. CARTWRIGHT (Wilmot Breeden Ltd.) wondered whether using the Hull cell with the bottom knocked out of it told a different story from a conventional Hull cell except the advantage of a degree of air agitation? On the other hand, the degree of air agitation which occurred with a Hull cell immersed in a plating tank of the size 4 in. x 6 in. x 6 in. did not, to his mind, represent any comparison with putting a Hull cell with the bottom knocked out inside a 2,000-gal. plating tank. Most people were interested not in a small cell but in something on a large scale.

He was surprised at the paucity of references concerned with the use of the Hull cell and with other work on throwing power generally. He would commend to the author a paper produced by *Professor Cuthbertson*, who was in the chair that day, which had been published almost ten years ago.

In Table I in the paper in the left hand column there was the name of the plating solution, and then there were three columns representing respectively nickel sulphate, nickel chloride and boric acid, and then a column headed " Other constituents." In the first column there were such entries as " acid copper," " Rochelle copper," and so on. On the next page he had been surprised to read, after the reference to methods of cleaning anodes and cathodes, the list which was given of standard plating conditions which had been used. These were as follows :

*p*H 4.00
Agitation (air) 1 l. per min.
Cell current 4 amp.
Plating time 1 hr.
Temperature 55°C.

He presumed that those were standard conditions for the nickel solutions. The paragraph went on to say " The following exceptions to the standard conditions were made, in order to conform with general practice," and again he presumed that that meant to conform with general plating practice, but for the standard chromium solution the plating time was given as 35 amp.-hr. Ampere hours was a measure of current passed in a given time, not a plating time. In the next column the author said " In agitation trials of the Watts nickel solution, air was passed at ranges of 0 1/min. and 2 1/min. It was difficult to tell from the way in which that was printed whether it meant 0.1 or 0 1 (meaning 0 litre).

Metallurgical Examination of Specimens

Again there was a comment about the metallurgical examinations of the specimens, and an etchent was given of 5 per cent sodium cyanide + 5 per cent ammonium persulphate. He would like to know whether this was a universal etchant for all the specimens, and he would also like to know the author's technique of mounting them. He had been surprised to read in the next paragraph that " Since copper facing deposits did not adhere to chromium plated cathodes, these were cut into pieces before the facing was applied." What was the facing applied in that case?

With regard to the reproducibility of the results, in Table V under throwing power T_5 the figures ranged from 5 to 11, with an average of 8. That seemed to be rather a wide scatter of results. The average of 8 was over a range from 5 to 11, meaning a variation of about 50 per cent, which seemed to be on the wide side for scatter.

On the question of addition agents, and particularly coumarin, he would like to ask whether the author had done any work on the effect of *p*H and the relationship between *p*H and the addition agents and throwing power.

It seemed to him that the paper had been produced and the results presented on statistically invalid information. He might be wrong on that and open to criticism himself, but in looking at Table VI, it would be seen for Watts nickel, 20 and 40 amp. per sq. ft., there was a star and a dagger and the star indicated that average values were given from two experiments and the dagger that the average values were from five experiments. It could only be assumed that the other figures given in the paper had been based on one experiment in each case. He might be wrong there, but that was the interpretation which he put upon that table. To present scientific work on the basis of one result only might lead to a great deal of trouble.

MR. E. A. OLLARD (Atlas Plating Works Ltd.), referring to the original BSI panel which had produced the definition of "throwing power" contained in the formula to which the author referred, said that when the panel had started on that work they would have liked to say that throwing power was a property of the solution and of the solution only, but with all the information which

they then possessed—and he was going back very many years, before some people in the audience were born—they had felt that was not so, and that throwing power was a property of the solution, but a property only under certain conditions of working. In their definition, therefore, it has been pointed out that any statement of throwing power must contain information about temperature, current density and so on. They had then evolved a definition which he thought was still accepted today, and he was surprised that the author, in putting up another method, which he agreed might have certain advantages, had not made any direct experimental comparison between what was today the standard method and the method which he put forward.

It seemed to Mr. Ollard that the first thing that it was necessary to know was whether the two methods gave the same figures. He could not find in the paper even one reference to that. Before making any definite statement it was necessary to have a whole series of figures obtained under different conditions to see how far the author's method corresponded with the standard method, because, if it did not, it would be necessary either to change the definition or alternatively to call it something else, because "throwing power" was a purely arbitrary thing which had been defined in a purely arbitrary way, so that if it was desired to alter the methods of doing it, and the altered methods did not give the same results, something had to be done about it.

That was his main criticism of the author's work, but there were one or two small matters which were of interest. In the first place, what sort of significance did the author attach to the figures given? In other words, was the alteration between, say, 15 per cent and 18 per cent throwing power something which was really significant? His own feeling was that the throwing power was an awkward thing which it was difficult entirely to get hold of and that very small changes in experimental methods would make an appreciable change in it. While he would agree that there was a very noticeable change in practice between +100 per cent and −100 per cent he doubted whether there would be any notable change in practice between, say, +3 per cent and +4 per cent. It would be interesting if the author would give some idea of what he considered to be significant, and whether or not he had any statistical information on that matter.

Throwing Power in Service

Finally, Mr. Ollard thought that too much emphasis had been placed on trying to measure throwing power under conditions of service. It did not seem to him particularly important whether the measurement was made in a tank or by taking something out and putting it in a little box, so long as the figure obtained gave a significant difference between solutions which were in fact performing differently in the tank. He thought that what was wanted was the easiest method.

The author's method had some advantages, but it had one disadvantage. From long experience in these matters, Mr. Ollard was not happy that it was as easy to measure a thickness of plating as a weight. It was possible to measure a thickness under the microscope at a particular point if the preparation of the specimen had not distorted it. He believed that the author's preparation had not done so, but some people might be less fortunate or less experienced. In any case thicknesses were inclined to vary on a strip of that type, and it was necessary to take dozens of measurements and even them out, and how the cutting was done might make a difference. With the standard method, however, it was only necessary to weigh it, and anyone could do that fairly accurately.

MR. T. E. SUCH (W. Canning and Co. Ltd.) said that in order to discover the mechanism behind the effect that organic addition agents had on the throwing power of nickel solutions the author had attempted to correlate the differences between cathode potentials found at different current densities, as given in Table X, with the percentage throwing powers in Table IX and suggested that the reason why for some addition agents quantitative agreement was not found between throwing power and difference in potential was probably that their effect on efficiency had not been taken into account. It might be significant that some German workers had come to the same conclusion in the East German journal *Deutsche Electrotechnik*, where *Bilfinger* and *Strauch* had recently published an article on the effect of organic chemicals on the throwing power of nickel baths. They had first measured the throwing power of various nickel solutions using the Haring Blum cell, but they had been unable to relate the results obtained with those found in practical tests in which the distribution of nickel deposits on a curved test-piece had been determined.

The authors then measured the difference in cathode potential δE at two different current densities in the same solution, but even those did not match up with the respective throwing powers of the various solutions as given by thickness distribution. It was not by varying the current density that a relationship could be found which placed the solutions in their correct order for throwing power. If the change in cathode potential δE was divided by the change in current efficiency, which they called δD, given by two different current densities, they claimed that the ratio $\delta E/\delta D$ would give the relative order of merit for throwing power for nickel solutions containing various

organic chemicals. Did Mr. Watson agree that the effect of current density on efficiency was as critical as the effect on throwing power, as *Bilfinger* and *Strauch* implied, or did he still feel that cathode polarization was much more important?

DR. T. P. HOAR (University of Cambridge) said that his first point was similar to one made by Mr. Ollard. In using the Field formula for throwing power applied to the Hull cell the author was using a formula which had originally been worked out and then employed for the Haring Blum cell. Dr. Hoar was not convinced, despite the very elegant determination of primary current density that the author had given, that it was right to apply either the original Field formula or the modified Field formula to a Hull cell, the reason being that in the Haring cell the two resistances of the two cathodes were entirely separate, whereas in the Hull cell the various resistances were in parallel and connected together in parallel across the whole of the cell. It would be necessary to have a much greater insight into the current distribution in the Hull cell and also into the theory accompanying it before it was possible to be certain that a formula such as the Field formula could be applied.

Second, he would like to ask whether the authors were really telling themselves very much more by adopting any formula for throwing power than could be found from the straightforward metal ratio on the near and far or outer and inner cathodes, depending on the type of cell used. It seemed to him that the figures of percentage for throwing power, although they had been useful in the past, were not what was wanted. What was required in practice was the metal ratio, and as determined by the present author the metal ratio in Table VI naturally followed throwing power. More simply, the actual current ratio, provided the cathode current efficiency remained the same at the two cathodes, could give exactly the same information as the metal ratio. He would be prepared to abandon the whole idea of throwing power through an artificial formula based on an artificial cell and merely talk about a metal ratio on two different cathodes, one perhaps shielded and one not, or one further from the anode and the other nearer.

For that reason he did not feel that Mr. Ollard's suggestion that they wanted to know the throwing power of a solution was entirely sound. Throwing power from the point of view of metal ratio depended, of course, upon size. In the formula which Dr. Hoar had worked out thirteen or fourteen years ago for the Haring cell he had used the current density ratio

$$\frac{i^1}{i^2} = \frac{R^2 + k(\delta E/\delta i)}{R^1 + k(\delta E/\delta i)}$$

where k was the conductivity of the solution, δE was the difference in potential of the two cathodes, and δi the difference in current; and in that formula, since $\delta E/\delta i$ was a cathodic polarization current, it was always negative, so that the second two terms were negative. If, however, the polarization curve had an infinite slope $\delta E/\delta i$ was very large, despite the fact that the ratio of the arms of the Haring cell was equal to 1. If, on the other hand, the polarization curve was very flat, and $k(\delta E/\delta i) = 0$, or nearly so, the throwing power was zero. It would be seen that better conductivity gave better throwing power. He believed that the ratio i_1/i_2 was a more interesting figure than throwing power, but he agreed that the ratio M_1/M_2 was what was really important. This formula still applied to metal ratio provided that the polarization curve with which one was dealing was the partial current for metal deposition and not the total cathode current including hydrogen deposition. That worked out in a very similar way to the German paper and would be found in the discussions of the Faraday Society in 1947.

"Throw"

Finally, interest was not in practice in what happened in a small cell with an anode quite close to the cathode, but in what happened at different parts of; it might be, a small cathode, such as a hub cap, which was in a bath and a long way from the anode. He was convinced that the proper way to investigate the throw—and he said "throw" rather than "throwing power," so as not to deny his statement that throwing power was not a helpful concept—was to take a cathode, put it on the cathode busbar and measure the thickness of metal on the inner bit and on the outer bit. It might be possible to develop a kind of split cathode. That was not new, but the particular way in which it was split would be, because one would put on a big guard ring and in that way measure two different currents at the same time and get at any rate an estimate of metal ratio and the exact current ratio from one single bit of metal which could be put into any plating bath whether it was 6 in. x 4 in. or 60 ft. long. He hoped to report on this in a paper to the Institute next year.

MR. S. W. BAIER (British Non-Ferrous Metals Research Association) thought that Mr. Cartwright and, perhaps, Mr. Ollard had to some extent missed the point of the paper. The author was saying something about what was called throwing power and giving some information about the effect of current density, about which there was very little in the literature, and also information about the effect of different types of nickel solution and what happened with the chloride and the sulphate and the sodium ions in it. Up until now there had only been a few figures, which had given a rough indication that acid copper was worse than nickel, and so on, but it was necessary

to know whether the distribution obtained on the article itself was the same as the distribution obtained in the Haring cell.

It was perhaps unfortunate that the author had had to use the old throwing power formula, but he had probably done so for lack of something better. The real point was that he had opened up the subject and shown the direction in which it was possible to go and how useful it could be. If a plater suddenly doubled his current density he might put on twice as much nickel as before, but it was quite possible that he was putting only 10 per cent more nickel on his recesses. That was the point which the author was bringing out, and it was an important one. No doubt the question of whether this should be expressed as throwing power or whether the Field formula or the original Haring Blum formula gave the information was a point for consideration, but it was necessary to be able to distinguish between the throwing properties of solutions and differences in the solutions and what happened to the addition agents.

MR. E. A. OLLARD (Atlas Plating Works Ltd.) said he liked very much Dr. Hoar's distinction between throwing power and throwing, because it seemed to him that these were two entirely different things. The idea of throwing power had been to compare two quite different solutions and give people an idea of how they would throw in a tank. The question of actual throw in the tank was another matter altogether. There seemed to be some confusion and they were not talking about the same thing. That was why he had said that in estimating throwing power he thought that it was not necessary to simulate practical conditions. With regard to practical conditions, when Dr. Hoar was doing his work he might keep in mind the question of barrelling, because it was possible in examining a barrelled screw to find that there was more metal on the bottom of a thread than at the top.

PROFESSOR J. W. CUTHBERTSON (University of Nottingham) did not think that there was any reason why the reference should have referred to his own work with the Hull cell. That paper in question was one which Professor Cuthbertson had produced out of his enthusiasm for the Hull cell as a means of control. He had always had a very great respect for it.

There had been a certain amount of criticism of the present paper, and he thought that that was justifiable. At the same time it must be realized what a pioneering instinct lay behind the work which the author had done. The author had displayed ingenuity in attempting to use this cell for a purpose for which it had not been originally designed. The main point in Professor Cuthbertson's mind about this work was that which had been raised by Dr. Hoar. He did not like tests done in small quantities, on small volumes of solutions, or at any rate tests of the kind in question.

In the Transactions of the Electrochemical Society many years ago, *Casbar* started with what he described as a finite linear conductor, a simple conductor with terminal electrodes at right-angles to the lines of current flow, and he pointed out with a drawing that tilting one of those electrodes even very slightly indeed involved enormous mathematical calculations to solve the problem involved. He worked out the full theory of the Hull cell, but it had never been published. Although the logarithmic formula was adapted for convenience and as something which gave a reasonably practical result, the fact remained that the Hull-cell mathematically was a most complex device.

Air Agitation

MR. S. A. WATSON, in reply, said that Mr. Cartwright had stated that air agitation was not representative of large tanks. The Hull cell had been in a small tank, but there was nothing to stop it being suspended in a large tank and, since all the sides were vertical, the effect was likely to be slight.

With regard to the references in the paper, there were some dealing with the Hull cell and throwing power, but it was essentially a research paper and not a review paper. He agreed that to give a plating time in ampere-hours could be objected to, and it should have been given as the product of plating time and current density. With regard to the agitation of the air and the passage at the top of the second column on p. 31, when he had received a galley-proof of the paper he had pointed out the possible confusion there and had suggested an alteration, but nothing had been done about it. The etchant used had been used for all the samples.

Mr. Cartwright had criticized the data in Table V and had said that the scatter of two or three units on either side of the throwing power of 8 represented 50 per cent. That was not significant; the point was that the throwing power was so low that the difference of two or three figures was meaningless. Reference to the actual data would show that the figures were fairly close. With regard to the objection that it was statistically unsound when only one or two experiments were done, it was clear from what was said that in one case five experiments had been done, and in another two, and the variations had been small. The differences between different solutions, and the same solution at different current densities, were by comparison very much greater and he did not think that it was at all necessary to do each experiment half a dozen times, because not much more information would be gained in that way. The effect of *p*H on coumarin had not been tried.

Mr. Ollard had commented on whether a change of 15 to 18 per cent was significant. Mr. Watson thought that it was not. He agreed that the metal ratio was more important than throwing power, but throwing power values were popular and were included in the tables. The metal ratios, however, were always given. An increase in the throwing power to 18 per cent was equivalent to an increase in thickness of the thin deposit of about one-quarter and increasing the throwing power up to 30 per cent would bring it up to an increase of one half in thickness at the thin region. From a corrosion point of view this was obviously significant, because the corrosion usually occurred where the plate was thinnest.

It was true that it was more difficult to measure thickness than weight, and it was pointed out in the paper that this was so. It was also stated that it should be possible to use non-destructive methods of measuring the thickness. Dr. Kutzelnigg had shown that the Magna gauge had been successfully used for that purpose.

Criticism had been directed to the fact that he had not compared the results obtained with the Hull cell with the Haring Blum box. He would have liked to do this, but the Haring and Blum was just as arbitrary as the Hull cell or any other arrangement. The fact that it had been discovered first did not give it any greater claim to represent absolute values. In any case the fact that the two cathodes were separate meant that the conditions in the Haring Blum cell were very different from those in practice where the cathodes were parallel. Since they were parallel and the path was almost common, it was possible to move the anode quite close to the cathode and not change the conditions. It seemed to him, therefore, that the use of the Hull cell was a fairly good approximation to what happened in practice.

Measuring the current ratio instead of throwing power was all very well if there was just one solution, but when comparing a variety of solutions, and in some cases having great variations in efficiency, this technique would not be acceptable at all.

As he had said already, his was a research paper and the conditions being examined had been very wide. It was well known that in any sort of investigation of plating work when results were transposed from a small to a large scale there would be a change, but it would have been quite impossible to do all the work described in the paper in a 100-gal. tank. If any of the results obtained were considered of interest by practical platers, they would want to try them out on a large scale. It was true that the mathematics of the Hull cell were complicated, but he imagined that this would also apply to plating an article in practice.

ABSTRACT NO. 7

DETECTION OF ZINC DIFFUSION INTO TIN COATINGS ON BRASS.

by S. C. Britton and M. Clarke.**

TIN coatings are widely used on brass articles such as tags and terminal parts to facilitate soldering. Brass may be tinned by dipping into molten tin or by electrodepositing. In the absence of a barrier layer, there is a possibility that zinc will diffuse from the brass into the tin coating, during hot processes or during storage.

Laboratory research into zinc diffusion and its effects is handicapped by the lack of easy means of detecting zinc in the surface of the tin coating. It has been known for some time that the corroding potential of tin-zinc alloys containing substantial amounts of zinc, remains close to that of zinc in neutral solutions but changes fairly rapidly from this value to one close to that associated with tin in acid solutions. The measurement of the corroding potential has therefore been explored as a means of showing the presence of small amounts of zinc in tin.

For rolled tin containing 0.1 per cent zinc immersed in sodium chloride solutions, it was found that initial potentials were much more negative than those of pure tin and that the potential change after immersion was accelerated by increasing the concentration of dissolved salt.

When electrodeposits of tin were tested, the initial potential of coatings deposited from alkaline stannate baths were found to be appreciably more negative than those of deposits from other baths or of rolled tin. It was unlikely that these deposits could contain zinc or amounts of any other codeposited metal sufficient to cause the potential shift; traces of alkali were thought to be the most likely agent and cleaning treatments were explored.

When tin containing as little as 0.025 per cent zinc is immersed in 0.001 per cent sodium chloride solution, its initial corroding potential with respect to a saturated calomel half-cell is around —900 mV. whereas for pure tin the potential is around —550 mV. The rapidity of the change of the potential with time appears to be an indication of the zinc content of the tin. It has been shown that the zinc contents detectable by the indications of corroding potential are sufficient to influence seriously the resistance of the coatings to condensed moisture.

Further work must be done before the full implications of the measurements on solderability can be stated, and this is being done. It seems worth while putting on record the possible usefulness of the method described in the article.

* Tin Research Institute

(1) The corroding potential, with respect to the saturated calomel half-cell, of tin containing zinc in 0.001 per cent sodium chloride solution at 25°C. is initially about —900 mV. The period of retention of this value before a rise to a tin like value of about —550 mV. is an indication of the zinc content. A zinc content of 0.025 per cent was easily detected.

(2) Tin coatings 0.1 mil or 0.2 mil thick direct on brass, flow-brightened, had sufficient zinc in the surface of the coating to be easily detectable by measurement of corroding potential.

(3) A flash of copper on brass before applying tin coatings prevented diffusion of zinc during the flow-brightened process.

(4) The detectable amount of zinc in the surface of flow-melted coatings of tin direct on brass increased substantially in the course of two years storage.

(5) The amounts of zinc detectable by potential measurements were sufficient to reduce the resistance of the coatings to corrosion in copious condensation of moisture and to make soldering more difficult after such corrosion. Coatings containing zinc but not exposed to condensation of moisture were easily wet by solder so that the effect of zinc content on ease of soldering is an indirect and conditional one arising only when severe corrosive conditions are encountered.

ABSTRACT NO. 8

THE SOLDERABILITY OF SOME TIN, TIN ALLOY AND OTHER METALLIC COATINGS

by C. J. Thwaites *

THE joining of surfaces by soft soldering is encountered in many different industrial applications, where the ease of soldering is of primary importance. It is usual to coat the surfaces to be joined with a metal which is easily wetted by molten solder, this in effect taking the place of a pre-tinning operation.

Storage has a detrimental effect on metallic coatings, particularly with coatings applied by electrodeposition. A laboratory study was therefore planned, but a complete simulation of the vast range of commercial conditions was impossible.

The spread-of-drop test was considered reproducible and the ultimate extent of wetting measured. It is believed that the rate of spreading is independent of the extent of spreading and no account of this was taken during the tests. It was decided to apply coatings to large panels and cut them into strips.

The investigation was designed to study the influence on solderability, of the following variables;

1. Type of coating.
2. Thickness of coating.
3. Type of basis metal.
4. Storage period.
5. Storage temperature.
6. Undercoat layers applied beneath the final coating.
7. Passivation or other protective treatments applied to the final coating.

Twelve types of coating were chosen, at three thickness levels on steel, brass and copper. Three types of undercoat layers were applied and some of the pure tin coatings were given three types of protective after-treatment. The samples were tested for solderability immediately after applying the coating and five different periods of storage, covering a period of two years at temperatures of 25 and 50°C. Some 8000 specimens were tested and metallographic examination undertaken to observe the formation and growth of intermetallic compound layers by diffusion during storage.

After coating, each panel was cut into twenty test strips, three random samples from each panel being tested for solderability within 48 hours. The remainder were stacked in open boxes and maintained thermostatically at 25 and 50°C. Specimens were removed and tested after 1 week, 4 weeks, 13 weeks, 52 weeks and 104 weeks.

Normal cross-sections and taper sections were taken from the specimens after different storage periods and microscopic examination was carried out to study the extent of diffusion occurring between coating and basis metal and also to study the effect of an undercoat layer on the amount of diffusion.

The results of the experimental work suggest that the following conclusions may be tentatively drawn :

1. Coatings of tin or alloys of tin with lead, zinc or cadmium generally give excellent initial solderability and retention of solderability when not less than 0.0003 in. thick.

2. Hot-dipped tin coatings are pre-eminent for solderability quality.

3. If solderability is the only criterion, tin alloy coatings have no advantage over pure tin.

4. There is no decrease in solderability of coatings on steel when applied correctly and stored under reasonable conditions.

5. With a brass basis, deterioration may occur in the solderability of electrolytic coatings after storage due to zinc diffusion and subsequent action of atmospheric moisture when storage conditions are unstable. A 0.0001-in. thick copper undercoat beneath electroplated tin or alloy coatings or a 0.0001-in. thick nickel layer under hot-dipped tin coatings alleviates this difficulty. In the latter case, contamination of the dipping bath by zinc is also prevented.

* Tin Research Institute

Sampling the local electrolyte are R. J. F. Gear (Engelhard Industries Ltd. (Baker Platinum Division)), A. W. Hurst (John Preston and Co. Ltd.), R. Rae (Westclox Ltd.), J. M. Shepherd (Malden Plating Works Ltd.) and W. B. Hanley (The Orcene Co. Ltd.)

6. A copper basis leads to a decrease in solderability due to loss of coating as tin-copper intermetallic compound, but this loss is only serious for coating thicknesses less than 0.0003 in.

7. A 0.0001-in. thick nickel undercoat gives enhanced initial solderability and no deterioration in storage of adequately thick coatings, but the final coating should be applied without too much delay.

8. A 0.0001-in. thick copper undercoat generally enhances the initial solderability of steel and brass but decreases in solderability occur on thin coatings, as mentioned in 6 for plating direct onto a copper basis.

9. Flow melted tin-coatings show slightly superior storage properties compared with as-plated coatings of a similar thickness, when both are on copper. On steel and brass, there appears to be no advantage of flow melting.

10. When the coating system has been chosen for reasons other than the simple attainment of good solderability and the possibility of deterioration has to be faced, storage should be at ambient or preferably 25°C., to prevent condensation and it should be for the minimum period. This applies particularly to brass and copper work. Humidity and atmospheric contamination should be kept low, perhaps by storing the coated work in inert containers embodying a desiccant.

DISCUSSION

DR. W. STEIN (Joseph Lucas Ltd.) dealing with the paper on solderability, said it always pleased him to see that someone had done serious work on soldering and the problems connected with it. Soldering was a process which, while carried out extensively in a number of industries, had not received much attention, and the feeling of many engineers, metallurgists and chemists seemed to be that soldering was more the concern of plumbers than technologists. Those who had to look into soldering difficulties in industrial production would know that nothing could be further from the truth and that soldering, though the oldest metal jointing process invented by man, still presented very real problems.

Early in the paper cetylpyridinium bromide was mentioned as an addition to the standard flux. As he took a paternal interest in this formulation, he would like the author to say what difference this activator made throughout the work described in the paper.

The spreading of a solder pellet was used as an indication of solderability. That had been, Dr. Stein believed, first used by Dr. Homer, although in a more primitive form. This type of testing had always been found to be simple and very reliable. He was less happy about the author's remark that low testing temperatures and minimum flux activity would provide the greatest sensitivity to small differences in soldering behaviour. In his experience such differences were easier to notice with solder of lower tin content, and, while he appreciated that the author might not wish to appear as an advocate of reduced consumption of tin, he might care to express an opinion on that observation with regard to lower grade solder as test material.

The work and results described in the paper were of great interest, and in particular the metal-

lurgical side contained much which had not appeared in print before. On the other hand, the observation that a brass base did not cause reduction in solderability of tin coatings during storage was surprising, and it had apparently surprised the author. He had had a great deal of trouble with tens of thousands of small components due to just this cause, so that he thought that that result required checking, as the storage conditions employed had apparently been nothing like so severe as those found in a factory. That might also account for the finding that coatings on steel did not change in solderability. Admittedly there was no diffusion or migration in this case, but oxidation and film formation under the influence of moisture would occur whatever the base metal or the intermediate layer might be.

In order of solderability he had always found tin to be very good, closely followed by silver and copper, particularly when the latter had a matt surface which greatly aided capillary flow. Cadmium was found to be much inferior. It was true that on test, tin or tin-zinc would give an area of spread greater than that produced on silver. It should be borne in mind, however, that for each individual soldering operation a certain degree of spreading and wetting was necessary, and that once those requirements had been adequately met a greater tendency to spread was not required and might actually become an embarrassment in some circumstances.

Types of Tin Coatings

It was not clear from the paper what differences, if any, the author found between the solderability of acid tin and of stannate tin coatings. He had always found acid tin less good, while tin produced from the chloride bath, which had still been in use in the 1940's, had been practically unsolderable with non-corrosive fluxes. On the other hand, the alkaline nature of the stannate bath made good rinsing imperative, and this was apparently more than many shops would do consistently. He could recall many instances of where soldering trouble had been caused by alkaline residue from the plating solution.

Zinc Estimation a Problem

Dealing with the paper by *Britton* and *Clarke*, he said that zinc had always been a difficult metal for the analyst. There were no easy methods of estimating or even detecting zinc. That unhappy position was probably the reason for the work described in the paper. The authors used the corrosion potential of zinc-containing tin coatings in their diluted sodium chloride solution as an indication of the quantity of zinc present. This was certainly a novel approach and the actual test should be easy enough to carry out. The question arose, however, of whether any allowance had been made for the possible influence of pinholes which might be present even after flow brightening, particularly in such thin films as the authors had used for their experiments.

Second, there was probably within the deposit a gradient of zinc concentration from the base towards the surface. If this were so, film thickness assumed added importance.

There were one or two remarks in the paper which he would like to emphasize. He fully agreed with the authors that too thin a tin film was often the cause of bad solderability. He had frequently found that a very thin film was worse than no plating at all. It also appeared from the author's comments that small proportions of zinc in tin could increase corrodability. It would be interesting to know the borderline from where onwards the addition of zinc became beneficial. As the authors said that they were doing further work on the subject, the results of their continued investigations would be awaited with interest.

Thin Oxide Layers

A SPEAKER referring to the metallurgical data, said he would like to stretch this to the limit. The difficulty of soldering seemed to be associated with two major features. The first was the very thin oxide layer which might be present on the coating, and the second the alloy composition of the coating resulting from storage. The relative importance of these two seemed to be confused. Talking about the composition of the coating resulting from diffusion, if it was important, what in fact was the critical tin content of the coating which just would or would not give spreading on iron, copper and brass? Would those compositions fit in with any feature on the appropriate equilibrium diagram of iron-tin, copper-tin and so on? Was complete solid solution necessary and how did the intermetallic compounds assist or obstruct the soldering? Lead was also present, and he assumed that lead played no metallurgical role other than having a low melting point. Finally, was it possible from published information to derive diffusion data of the tin inwards to the basic metal or the basic metal out to the coating? The diffusion rate seemed to have a high temperature coefficient. Arising from that, at what temperature did the author consider that diffusion was unlikely to occur to any significant extent?

MR. C. J. THWAITES, replying to Dr. Stein, said at the beginning of the work described it had been decided to use pure resin flux all through, but when soldering tin-nickel alloy plating it was found that it was not solderable with a pure resin flux but only with an activated resin flux, and therefore it had been necessary to introduce an

activated resin flux for this purpose. To obtain some method of comparison a retest was done on some of the cadmium plating with the activated flux and it was found that it caused a slightly better spread compared with that obtained with pure resin. On other materials he would say that the effect was very small on the area spread.

On the question of whether to use a lower tin content solder, as being a more sensitive test of solderability, he had not enough practical information to agree or disagree with that suggestion. The reason for choosing a eutectic solder was that this was the common one used in the radio and electrical industry for soldering, and it seemed to be a reasonable solder with which to carry out the requirements, but possibly other factors might have been shown up by using a particular solder, but that would have meant further complications.

On the question of the relative merit of different coatings, Dr. Stein said he had always found tin to be closely followed by silver and then copper. Mr. Thwaites would increase the gap and say that silver was nowhere near as good as tin. Cadmium had been found to be intermediate between silver and tin. Silver seemed to be particularly obstinate whatever the thickness or the base metal ; it had been found poor all the way through. The point should be mentioned that sometimes a good spread was not wanted. He had come across that problem ; people had said they wanted to make a solder joint but the solder must not run through and come out at the other side. He did not propose to go into the details of that because each case must be taken on its merits. Finally, it had been found that on an average acid tin plating was slightly inferior to the stannate, but in practice if one had not a qualified staff stannate plating might be inferior. Under laboratory conditions stannate plating was definitely a little superior to the acid plating.

Dealing with alloying and oxide formation, Mr. Thwaites said that alloying and diffusion would occur, however the material was stored. Oxygen formation would depend entirely on storage conditions. It was important to avoid confusion in this matter. If storing was carried out at a high temperature there would be rapid diffusion of the coating, and if storage was done under conditions such that oxide formed rapidly quick soldering would not be possible. The question of intermetallic compound formation had been covered fairly well in the paper. He would not presume to answer the question of what was the mean tin content of the coating.

Diffusion Direction

With regard to diffusion direction—whether the tin went into the base metal or *vice versa*—he would only say that at present they were starting a major research on the diffusion of tin coatings with various base metals and as yet they had no information worth giving on the subject. The chief difficulty was that intermetallic compounds grew as little crystallites and therefore it was not possible to measure an average thickness. It was necessary to work out entirely new techniques for measuring diffusion rates and diffusion directions. In this work they hoped to use radioactive tracer techniques. On the question of the effect of temperature on the rate of diffusion, it was stated in the paper that for one particular coating the same effect was obtained by ageing for two years at 25°C. as would be obtained in three months at 50°C. That was the nearest to a quantitative figure which he could give.

Detection of Zinc by Chemical Means

Dr. A. Kutzelnigg (Siemens-Schuckertwerke, Nurnberg) made a suggestion concerning the detection of small amounts of zinc in tin by chemical means. A strip of filter paper impregnated with Dithizon (a well known organic reagent) was dried and immediately before use wetted with an organic solvent such as cyclohexanon on the metallic surface. The green colour of the wet paper changed to red in the case of zinc or zinc alloy. The reaction being very sensitive, it was possible that small amounts of zinc in tin might be detected by this non-destructive method.

Dr. P. Baeyens (N. V. Philips) expressed the opinion that Mr. Thwaites had been a little unfair in presenting his paper before an audience of electroplaters who knew almost nothing about soldering. It made things too easy for him. Dr. Baeyens confessed that he was one of those electroplaters who knew very little about soldering, but such information as he had related to about two million soldering operations a day, and when he studied a paper such as that now under discussion the first thing he did was to look to see whether the integrated information which he possessed was covered by the information given in the paper, and then he knew where he stood. In this case there was no such covering. As Dr. Stein had already pointed out in the discussion, silver stood much higher than had been found in the author's experimental work, and that cast some doubt on the method used in regard to whether or not the conclusions arrived at by that method could be applied to practical soldering problems. Moreover, when soldering was done on printed wiring panels the whole range of values was changed once more and it was found that lead-tin coatings and tin alloy coatings, and particularly lead-tin with approximately a 50/50 composition, were very good, either electroplated or hot-dipped. After that came a big mass of coatings or metals such as copper, silver, cadmium and other tin alloys which

were approximately equivalent, while pure tin, either hot-dipped or electroplated, was the worst of all. Apparently a good deal of further work would have to be done if research workers such as the author wished to provide information which could be used in practice in predicting the behaviour of electro-plated coatings.

MR. R. W. GOWER (C. A. V. Ltd.) commenting on Mr. Thwaite's statement that in a few tests an activated flux was used, asked whether the author could give an indication of specific instances. For example, was it used where the non-activated flux failed to give results, and, if it produced results, how was this considered in relation to estimation of solderability? Were the final assessments made from results obtained with the non-activated flux alone? His own company had had problems where the use of activated fluxes had produced corrosion in service and premature failures, especially since intricate electrical assemblies might not be washed and dried out after soldering.

Flow Melting

Second, dealing with flow melting in hot oil, had the test samples been stored with a film of oil in contact with them, or had they been de-oiled immediately after flow melting and then stored before solderability had been assessed?

Third, had the author at any time considered the use of a so-called dewatering fluid which left behind a positive film of oil or wax, as distinct from a lacquer film, after washing plated items, afterwards storing and solvent degreasing them prior to soldering?

Finally, was there any definite evidence of correlation between spread of drop, strength of bonds and quality of bond? Mr. Gower had been told that it was quite often possible to have what appeared to be a good joint, only to discover that a dry joint was present.

MR. W. MARCHAND (Standard Telephones and Cables Ltd.) said that anyone concerned with the manufacture of electronic equipment would be aware of the problems associated with soldering components, and particularly, as had already been mentioned, the soldering of components to printed circuits. In fact, in many instances there had been a change in design, because of this difficulty, by using the wrapped wire technique and therefore eliminating soldering altogether.

The main problem associated with this was undoubtedly the thin tin coating on the lead-in wires of certain components. In some cases the thickness of tin had been found to be even less than the minimum tested by the author, *i.e.* 0.00005 in.

It had also been interesting to note the results obtained using silver, which had confirmed his own experience; he had found that there was far less trouble in soldering silver after prolonged exposure than was the case with tin. In other words, in the tests there had been no change although the initial solderability might not have been so good. It was unfortunate that the author had not included gold in his investigation. Gold was being used to an increasing extent in the electronics industry not only because of its excellent solderability but also because of its good electrical characteristics, its resistance to tarnishing and corrosion, and also because it was not susceptible to whisker growth. The proneness of tin to whisker growth had banned its use on electrical equipment.

The author had been particularly fortunate in the storage conditions which he had chosen, which appeared to prove that under those conditions the diffusion of zinc into tin coatings was not detrimental. He had recently carried out some tests on scratch-brush tin-plated coatings to determine the cause of the formation of brown film during storage.

A number of panels had been plated with from 0.0004 to 0.0007 in. of tin on nickel copper and direct on brass; they were scratch-brushed and packed in various types of pack and stored under what they would call normal factory conditions for a period of about six months. In every case the scratch-brushed tin on copper, on brass and on nickel on brass, remained bright and the solderability virtually unaffected, whereas with the tin direct on brass the tin took up a brown colouration with a corresponding drop in solderability. He felt, therefore, that the importance of an undercoat of copper or nickel should be emphasized, rather than the storage conditions. In any case it would not be practicable, as had been suggested, to depend on storing parts in sealed polythene containers containing desiccant, as in many instances there was a long period between starting an assembly and finishing it, and in many cases spare connexions had to be left on equipment for the subsequent addition of further equipment.

"Normal Storage Conditions"

He had one point on the paper by *Britton* and *Clarke*. On the question of storage, he would like to ask these authors exactly what they meant by "normal storage conditions." He suggested that under what were generally accepted as normal storage conditions the presence of small amounts of zinc in tin coatings was detrimental, and it was only under abnormal storage conditions that a tin coating might not be adversely affected by the presence of small amounts of zinc.

MR. E. A. OLLARD (Atlas Plating Works Ltd.), asked whether the research workers at the Tin Research Institute had any experience of their bright tin process for soldering. His own firm

were at the moment, he said, bright tin-nickeling a zinc object for a customer. He did not know whether the customer wanted to solder it or not, but it seemed to him from the discussion that this might be quite a problem, because in the first place the zinc diffusion would be even more on zinc than on brass and addition agent films might produce a nasty coating which would make soldering difficult.

MR. C. J. THWAITES, in reply, said that Mr. Gower had asked about the effect of using activated resin fluxes. He had tried almost all of them and found that the effect of the activating agent was to produce a benefit of not more than 10 to 15 per cent, which he considered to be insignificant. He thought that the work reported in the paper had given some indication of trends and might help as a guide.

On the question of flow-melted tin castings, all the samples had been degreased and stored in a grease-free condition. He had not tried dewatering oils which left behind a waxy deposit ; the only one tried left a resin-type of deposit. This had been recommended to one firm who had been in trouble with deterioration in storage and it had seemed to be the answer to their problem, because the firm had had no trouble since they had dried off their plating and packed in a dewatering lacquer. No great benefit or disadvantage had been found from the dewatering lacquer, and in certain conditions it could apparently be a useful process.

On the question of correlation between area of spread and strenth of joint, probably there was not much correlation. If strength was required in a joint, the joint should be designed for mechanical strength. In most of the applications which had been considered, what was wanted as regards the solder was to make an electrical connexion and the amount of mechanical strength of the joint was obviously fairly limited.

In reply to Mr. Marchand, trouble with lead-in wires which would not solder was quite common and Mr. Thwaites agreed that the thickness of the tin coating on copper wires used for lead wires in condensers, resistors and so on might often be as low as 0.00003 in. If the cross-section of such a wire were examined it would be found that the tin was distributed in a few odd ridges down the wire and the rest of the wire was more or less bare intermetallic compound. In those conditions the solderability was not so good as would be desired.

Tinning Wire

At the Tin Research Institute a study was being made of the problem of tinning wire and it was suspected that in order to be able to produce what could be considered a reasonably thick coating it was necessary to have a concentric envelope round the copper. That might sound easy, but it was in fact extremely difficult.

With regard to the order of merit of tin, silver and so on, this question had arisen over and over again. He felt fairly happy that the results gave an order of merit under the particular conditions of test at any rate, but he would not like to say that the best one was excellent and the worst was appalling. It would be unwise to say that because silver was at the bottom of the list it must therefore be bad. The order must be regarded as an order of merit which would shift up and down according to the application, but it was important that they had found that silver did not alter in solderability whatever was done with it ; whereas tin might deteriorate, silver was not affected by anything except, presumably, sulphide films, which they had never obtained.

On the question of storage conditions and the fact that extremely good storage conditions apparently had been used, the only retort was that it was necessary to start somewhere. It was no good saying that they would store some of the specimens with controlled humidity and others with higher temperature and cyclic humidity, because it would have meant too many variables. It was necessary to start with the inherent or basic solderability of these materials, and to follow that up they might start using different atmospheres. At present they did not intend to play about with different atmospheres, but the commercial tests which he had described might throw a little light on the subject.

He was glad that there was agreement with Mr. Marchand that it was a good thing to have an undercoat. Mr. Ollard had referred to bright tin. The authors had carried out a few soldering tests and on copper it had been excellent after six months storage, but on brass and zinc possibly Mr. Britton would be able to say what had happened.

Gradient of Zinc Concentration in Tin Coatings

MR. S. C. BRITTON, replying to the discussion on the paper by himself and Mr. Clarke, said that Dr. Stein had referred to the gradient of zinc concentration which must exist in the tin coatings after a period of storage. Such a gradient did of course exist. The method did not detect it, but one reason for using the method had been to obtain the information which was being sought rather than to make an analysis of the coating. There were also pores in the coatings, but the authors had felt confident that the pores did not contribute significantly to the results obtained. With the very dilute electrolyte used with quite high electrolytic resistance it was felt that little contribution was made by the pores, which were small and connected to the surface by quite high electrolytic resistance.

Dr. Stein had rightly emphasized the need for having ample thickness of coating, both because it took longer for the zinc to come through the coating and for the reason that if there was a sufficiently thick coating even the presence of a corrosion film on the surface by exposure to moist conditions would not necessarily interfere with soldering. If the coating was thick enough to become a little mobile as it melted, say 0.0003 in., it would crack the film of corrosion products and solder could penetrate. Adequate thickness was most desirable on that account.

Dr. Stein had also raised the question of where the concentration of zinc might be found at which the corrosion resistance of tin-zinc might be improved. That question might arise from a slight misunderstanding of the function for which tin-zinc alloy was deliberately used. The benefit obtained from tin-zinc alloy coatings was that they would protect steel when they were plated on steel, and that protection was given by the corrosion of the coating. It was not possible to have it both ways. One put something there to corrode in order to give some protection to the steel. Tin-zinc coatings were not immune from the effect of storage under conditions of exposure to moisture ; on the other hand, in dry conditions it had been found that very small additions of zinc tended to slow up the oxidation of tin at least at elevated temperatures. This had been studied for the range 150 to 200°C., which was above the range considered in the present paper, because there it was possible to see the effect by colour change. It had been very difficult to measure the changes by thickness measurements and other characters. Zinc had a useful anti-corrosion function in helping to reduce oxidation. There were also reports from other sources that round about the 20 per cent of tin used in tin-zinc coatings there were certain characteristic changes in the effects observed in anodic oxidation. He was not prepared to pronounce on the significance of those changes, but from the point of view of the present paper it could be said that there might be a lower limit, though it was very small, before there was formation of a zinc corrosion product. Towards the upper limit it got steadily worse as the zinc increased.

Dr. Stein had expressed interest in the further work that was to be carried out. It was important to put it on record that when copper diffusion reached the surface in the form of intermetallic compound, the detection of zinc by the method the authors proposed might become more difficult. The method and observations to tin-load alloy coatings had also been extended, and results of the same kind were obtained, although it should be added that the tin-load coatings themselves were without any diffusion in some circumstances. Particularly where there were organic acids present there might be some interference with the corrosion product without any diffusion.

Dr. Kutzelnigg had at an early date taken an interest in oxide films on tin, and his suggestions were to be welcomed. The authors had been aware of the possibility of some chemical detection of zinc in tin coatings, but had rejected them because they had felt that the good ones might be too sensitive. They were always faced with this difficulty. Great care had to be exercised about what was done in the laboratory before one could be sure of the results. It was hoped to obtain a semi-quantitative method for the estimation of zinc, and what might be called a quarter-quantitative method had been obtained. In view of the finding that zinc detection could be interfered with by copper diffusion, it would be necessary to look again at chemical detection and Dr. Kutzelnigg's suggestion would be most valuable.

Mr. Marchand was perhaps quite right in saying that the authors should not have described the storage conditions as normal under which no corrosion of the zinc or contaminated surfaces had been obtained. Perhaps the conditions should have been described as conditions which ought to be normal, but they were not. It was extremely difficult in commercial practice to ensure really satisfactory storage conditions and the only remedy was to increase the thickness of coatings and to use undercoats where possible.

Soldering Bright Tin

Mr. Ollard had referred to the soldering of bright tin. On copper, as Mr. Thwaites had said, the bright tin coatings had soldered satisfactorily and were used in practice to a limited extent. On brass and zinc the position was rather difficult. It had been found, in continuing the work described in the paper, that diffusion into the bright tin coating was appreciably faster than into conventional tin coatings. For that reason, the authors recommended, even when solderability was not concerned, that an undercoat of copper or nickel should be used for bright tin when it was deposited on brass.

MR. OLLARD said that in the case to which he had referred there was an undercoat of copper of about 0.0003 in.

MR. BRITTON replied that in that case it should be perfectly satisfactory. They had not found slight contamination by the addition agent to affect the issue markedly, except perhaps sometimes, so far as appearance was concerned, there might be a dark ring.

(*To be continued*)

A Quarterly Survey of some of the Features in Finishing Literature from Abroad

by **SCRUTATOR**

PROBABLY the most significant event in the metal-finishing sphere which has taken place so far this year is neither technical nor commercial. It is in fact connected with business ethics. In America the Directors of the National Association of Metal Finishers have published on an industry-wide scale a code of ethics and a set of trade practices[1]. These are primarily intended for the Jobbing Plating industry and their form as finally approved followed nearly 2 years' research and study by the ethical standard practices sub-committee of the National Association of Metal Finishers. The code of ethics consists of 2 parts, namely (a) " A Metal Finisher's Ten Commandments " and (b) a 3½-page document covering trade practices ; both of which received proper legal clearance before publication.

In publishing this information the Association stress that their aim is " to further truth and promote interests of all engaged in the fields of electroplating, metal finishing, buffing, polishing and allied arts." Additionally, another feature made is " for more honourable competition." Standard terms and conditions of sale are also included and it is advocated that these should be adopted and printed on the reverse side of quotation forms.

It is a sad reflection on the metal-finishing industry that the business methods of some of its members in general, and jobbing platers in particular, are such as to cause their trade association to issue such publications. " The Ten Commandments " and the code of practice are of course perfectly reasonable and just ways of conducting business. The tragic thing is that going into print at all implies that such ethics and codes of practice are far from being the general rule, and is a disturbing indictment of the American Jobbing Plating industry. Let us hope that this move will rapidly lead to improvements on both sides of the Atlantic. Surely however " education " of the buyer is just as important, if not more important, than getting the Jobber to put his business in order.

Nickel Plating

Unfortunately, the quality of " chrome " plating, particularly on car parts, is one of the major causes of general complaint against the plating industry. At a fairly recent meeting held by the American Zinc Institute in Detroit two papers were presented designed to help to restore confidence in chrome-plated zinc base die-castings—especially in the automobile industry. In the first of these, Caldwell and Sperry[2] presented the results of electrographic printing, Corrodkote and Cass tests on several types of chromium plating over duplex-plated zinc-base die castings. The standard basic process consisted of 0.008 in. of duplex nickel over 0.0004 in. of copper to which different thicknesses (0.010-0.050 mil) of chromium were applied from four different plating baths. They concluded that 0.010 mil of sulphate-type chromium plate appeared as good as any of these tested over duplex nickel. In the other, Safranek, Miller, Hardy and Faust[3] reported on the performance of 46 different plating systems and found that although duplex nickel coatings are efficacious, they only perform effectively when they are plated with 0.02 mil or more of chromium. A composite of bright nickel and 0.055 mil of chromium was also effective in preventing corrosion during accelerated tests and outdoor exposure.

Turning to the nickel plating solutions themselves, in the search for greater efficiency work has been carried out on phosphate, pyrophosphate, sulphamate and fluoborate solutions etc. and now some Russian experiments on the use of ammonium salts and reverse current as a means of obtaining bright deposits have been reported[4]. It was established that satisfactory nickel deposits could be produced and the reasons for the apparent discrepancy between structure and some of the properties of the coating are discussed. It is also suggested that the essential conditions for the formation of bright deposits from baths without brightening agents when using the reverse current method are passivation of the cathode surface during the anodic phase of the current.

Aluminium

Reverting to motor cars again, the controversies over the respective merits of brightened and anodized aluminium and chromium plated trim appear to have subsided a little. During the heat of the battle much was, however written on brightening,

(*Continued in page* 246)

AUTOMATIC PLATING OF DOMESTIC APPLIANCES

Details of New Equipment Installed at

A. E. I. - HOTPOINT LTD.

PARTICULARLY high finishing standards have always been a feature of Hotpoint electrical appliances but until recently, all plating at the Hotpoint Factory was carried out in manually operated equipment. At the end of 1959, however, an automatic unit was installed and in operation. The new plant — a " Trojan " for copper, nickel and chrome — has been installed in what was the old chrome plating shop. By careful planning and liaison, the manual plant was removed, re-sited and the automatic unit installed without losing even one hour of production. The new plant was supplied by W. Canning and Co. Ltd.

The new plant is a " return type " unit and has a compact centre section which dispenses with the normal permanent central structure extending above tank level. The centre unit consists of a simple system of hydraulic lifting cylinders underneath the carriage which raise it to give the required clearance for the transfer of jigs from tank to tank. The lifting cylinders operate on a low-pressure hydraulic system through mechanically-operated valves and are interlocked by a rack-and-pinion mechanism which ensures that they are permanently in phase. There are no flexible connexions, the pressure and return lines being carried by telescopic tubes.

The work to be plated is loaded onto jigs and the jigs then attached to workarms running in tracks on the side of the carriage.

Each workarm carries two jigs, each of which has a plating capacity of four square feet of work and the plant has an output of 72 jig loads per hour. Transfer of plating jigs is effected by hydraulically operated traverse bars ; conveyor chains, counter-balance weights and solenoids are entirely dispensed with and the number of limit switches used has been reduced to one single unit, therefore the sources of possible desynchronization are eliminated. Each transfer can be independently adjusted as the positions of the tanks in the plating process require. The hydraulic gear which operates this lift and traverse mechanism is carried on the centre structure independently

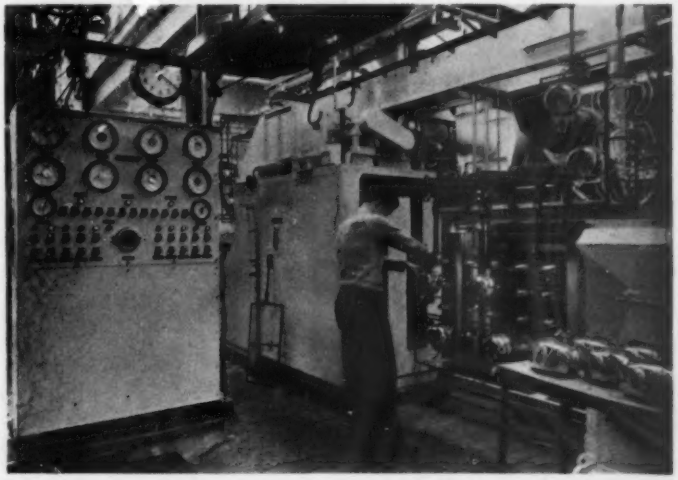
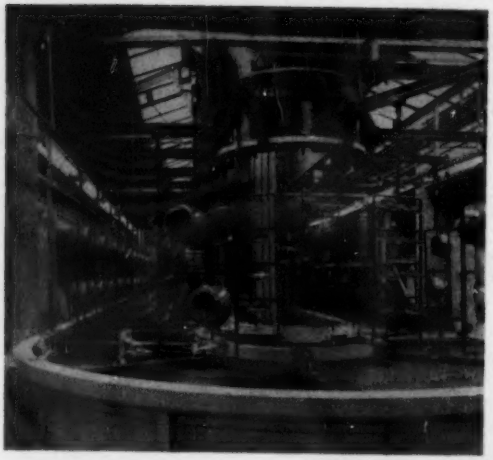


Fig. 1.—Loading and unloading station showing drying oven and, on the left, the master control panel.



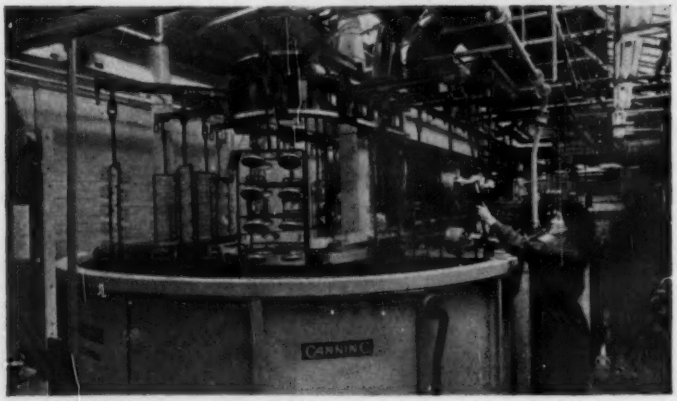
of the process tanks and is powered by a motor unit remote from the plant. The only parts of the unit which overhang the tank in any way are the workarms which carry the plating jigs. This is an obvious advantage from the point of view of reducing corrosive attack on operating mechanism, carriage gear and supports. It also fully eliminates the possibility of solution contamination arising from oil drips. The tanks around the plant are fabricated in units designed to enable them to be withdrawn from the process lines at any time in order to enable inspection and maintenance to be carried out.

The process sequence is under the control of an electronic timer which permits variation of process timing if required. The entire power supply for operation of the plant is provided by one hydraulic pump, which is powered by a 10-h.p. electric motor.

Fig. 2 (above).—View of the cleaning and copper plating section of the installation showing kettle bodies passing to the nickel-plating section.

Fig. 3 (below).—Operator attaching the internal anode before nickel plating

Fig. 4 (right).—The chrome plating and neutralizing section of the plant, showing the operator at the point at which the internal anode is removed after nickel plating.



Hot process tanks are steam-coil heated under thermostatic control, except for the bright nickel tank, which has a heat exchanger. All the tanks are of welded steel, the tanks for copper and nickel processes being hard rubber lined. The chrome process tanks are lead-alloy lined and plastic screened and an efficient extraction system removes all fumes to give a clean and wholesome working atmosphere.

Electric current for the cleaning and plating processes

(*Continued in page* 242)

AUTOMATIC *p*H REGULATION OF NICKEL-PLATING SOLUTIONS

By GUNNAR GABRIELSON

Summary

The effect of variations of the pH value in nickel-plating baths are described. The fundamentals of automatic pH regulation are presented and practical points of view for the equipment are set forth.

Introduction

ELECTROPLATING baths, from the point of view of this article, may be conveniently divided in acid, neutral and alkaline types [1] having *p*H values lower than 2, between 2 and 8, and higher than 8, respectively. Examples of acid baths are chromium and acid-copper plating baths, whereas nickel-plating solutions are neutral and cyanide solutions of various metals (*e.g.* cadmium, copper, silver and zinc) are alkaline.

In acid copper-plating baths the acid prevents the formation of insoluble basic copper sulphate ; moreover it increases the conductance. The concentration of the acid is, however, not critical but may vary between rather wide limits. In this case automatic *p*H-control is therefore meaningless.

The alkaline, *i.e.* cyanide-containing, baths usually have *p*H values of 12 and higher. In this range the continuous measurement of *p*H is rather difficult, as the glass electrodes used do not function very well at this high alkalinity. For the control of the alkalinity of these baths, therefore, titration methods are used.[2] Moreover, the *p*H values of these solutions ordinarily are not critical.

Generally, it is the *p*H of the neutral baths which is automatically regulated. By far the most important of these are the nickel-plating baths and it is the *p*H control of these baths which is discussed in this paper.

Effect of *p*H Variations in Nickel-Plating Baths

Whereas in the older nickel-plating solutions the *p*H value generally varied between 5.4 and 5.8, the *p*H values in the modern bright nickel-plating baths are lower, being usually in the range 2.5 to 4.8, the optimum value being about 3.5.

If the *p*H value rises to above 6 nickel hydroxide begins to precipitate, causing grey, dull deposits. This basic precipitation may also be included in the deposits, giving the nickel layer a very unattractive appearance through pittings and rough surfaces. With increasing *p*H value in the bath the anodic polarization also increases, *i.e.* the nickel anodes become passive.

At a lower *p*H the precipitation of basic compounds is prevented and the nickel anodes dissolve smoothly. The increased hydrogen content of the solution increases the conductance of the bath, as the hydrogen ion has much the highest velocity of all ions. This means that a higher current density may be used (up to 10 amp per sq. dm.), which is the most important advantage of the low-*p*H baths.

As the *p*H value of the nickel-plating bath is further decreased the discharge of the hydrogen ions at the cathode increases, owing to the fact that the discharge potential of an ion is a function of the concentration of this ion. This means that the current efficiency with regard to nickel is lowered in too-acid solutions. Moreover, the hydrogen evolved causes pitting of the nickel deposit.

Of the above it is seen that, from both technical and economical points of view, it is necessary to choose an intermediate *p*H value in nickel-plating baths. As already mentioned this *p*H range is between 2.5 and 4.8 in modern bright nickel-plating solutions, where the hydrogen-ion concentration is sufficient to permit a high current density and prevent hydroxide precipitations, but not so high that pitting, due to the discharge of hydrogen, occurs. In order to keep the *p*H value of these baths between the desired limits they are usually buffered.

A buffered solution is one whose hydrogen-ion concentration will change only very slightly when small amounts of acid or of base are added. The buffering agent used in nickel-plating solutions is boric acid. By this addition the tendency for rapid changes in the *p*H value to occur is greatly reduced. Boric acid is therefore very important for the automatic control and regulation of nickel-plating solutions. The presence of boric acid is also conducive to the production of white, smooth deposits.

Automatic *p*H Regulation

Under ordinary conditions there is no tendency for the nickel-plating bath to get more acid. The

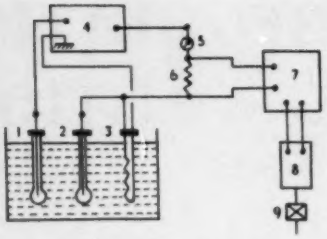


Fig. 1.—Schematic drawing of equipment for automatic pH regulation.
1. Glass electrode. 2. Reference (calomel) electrode 3. Thermo-compensator. 4. Amplifier. 5. pH indicator. 6. Resistance. 7. Regulating instrument. 8. Electro-pneumatical device. 9. Valve for the acid.

*p*H value normally rises slowly during the electrolysis, because the current efficiency is always less than 100 per cent, *i.e.* hydrogen ions are discharged together with the nickel ions, this discharge of hydrogen ions causes the *p*H value of the bath to rise. For automatic *p*H regulation the desired *p*H value is adjusted, and when it rises too high, electrodes in the solution give an impulse to a valve which opens and acid is added ; at the right *p*H value the valve is shut again. In order not to get too acid a solution it must be buffered so that the *p*H value sinks relatively slowly with the acid added. The lowest value in an automatically controlled bath is therefore only slightly lower than the desired one. In an unbuffered solution the variations about the desired value are much larger, possibly giving too large a hydrogen discharge.

A schematic representation of the electrometric method of *p*H measurement is shown in Fig. 1. The basic principle is that an electrolytic cell, composed of two electrodes immersed in the solution to be measured, develops voltage in relation to the *p*H of the solution. (The two electrodes will be described in some detail below). The voltage between the electrodes gives rise to a current, which is amplified and the output current from the amplifier passes to a galvanometer with a *p*H scale, and to a regulating instrument, on which the desired *p*H value is set. When this fixed *p*H value is surpassed the regulating instrument sends a current through an electropneumatic instrument, where through an electromagnetic device for compressed-air valve is opened to a bigger or less degree whereby acid is added to the nickel plating solution, through a further valve, controlled by the compressed air. When the acidity of the solution is the desired one no current passes from the regulating to the electro-pneumatic instrument, the passage for the compressed air is shut and thereby also the valve through which the acid is added.

The electrodeposition from the bath now occurs without addition of acid until the *p*H value again has risen above the desired one, when the above described procedure is repeated. As necessarily some time must pass from that moment when the *p*H value rises above the desired one until the valve opens and acid is added the *p*H value rises some tenths too high. On the other hand some time elapses from that moment when enough acid is added until the valve is shut, causing the solution to be too acid. It is therefore very important that the solution is well agitated, otherwise the bath in the vicinity of the valve may be too acid but the solution where the electrodes are situated too alkaline, so causing the addition of too much acid. When the solution is effectively agitated the added acid is almost instantly distributed through the whole solution and the valve shut within a short time. The *p*H value of an automatically regulated nickel-plating bath, rightly

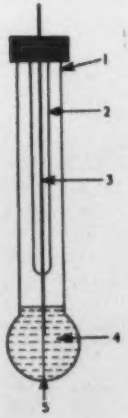
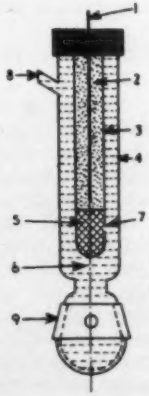


Fig. 2A. (left)—Glass electrode.
1. Outer glass wall. 2. Inner glass tube. 3. Platinum wire. 4. Buffer solution. 5. Thin glass membrane.

Fig. 2B. (right)—Reference (calomel) electrode.
1. Platinum wire. 2. Mercury-calomel paste. 3. Inner glass tube. 4. Outer glass wall. 5. Glass wool. 6. Saturated potassium chloride solution. 7. Liquid junction to sealed internal. 8. Refilling of potassium chloride solution. 9. Glass sleeve junction.



buffered and effectively agitated, may therefore vary only some tenths above and below the desired value, the electrodeposition therefore being performed *e.g.* in the *p*H range 3.5 $\pm$ 0.3.

The Electrodes

The glass electrode (Fig. 2A), consists of a glass tube, the end of which consists of a bulb of very thin, *p*H-sensitive glass, filled with a chloride solution buffered to a fixed *p*H value. Into this buffer solution a silver-chloride-coated platinum wire dips. This wire is in an inner glass tube and connected by an insulated cable to the amplifier. The thin, outer glass membrane is permeable to hydrogen ions (but not to other ions) in the nickel solution. As the number of hydrogen ions passing through the membrane depends upon the hydrogen-ion concentration in the outer solution, and as the potential of the electrode changes with the proton content in the inner solution (*i.e.* in the glass bulb) the potential variations are consequently directly related to the hydrogen content of the outer solution *i.e.* of its *p*H.

The calomel reference electrode, (Fig. 2B), completes the electrical circuit, the potential of the glass electrode being measured against the reference electrode which has a fixed potential. The most commonly used reference electrode is the calomel electrode, which consists of a tube packed with a paste of mercury and calomel (mercurous chloride, Hg_2Cl_2). The connexion to the outer circuit is through a platinum wire, which dips into the mercury-calomel paste, which is in contact with a saturated solution of potassium chloride. The latter, "inner" solution is used to provide a "liquid junction" between the calomel electrode and the outer, process solution, the *p*H of which is to be measured. The contact between these two solutions is very important for the right functioning of the electrode. The two types of contact, which are most widely used, are seen in Fig. 3. In Fig. 3A the connexion occurs through a porous fibre, *e.g.* of asbestos, or through a diaphragm of a porous sintered material. This type of electrode is rather sensitive for impurities, which clog the opening causing totally erroneous *p*H recordings. In solutions where insoluble impurities may be formed, *e.g.* nickel-plating solutions (formation of insoluble nickel hydroxide) this type of electrode ought to be avoided.

The connexion between inner and outer solutions which is schematically drawn in Fig. 3B, is much more suitable for solutions where insoluble impurities may occur. The contact between the potassium chloride solution and the process solution is here accomplished through a glass sleeve junction. The contact surface between the two solutions is therefore much larger than in the type described above and consequently much more insensitive to blocking by impurities

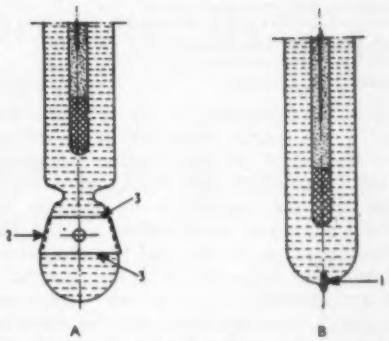


Fig. 3.—Different junctions between inner and outer solutions.
1. Porous fibre or diaphragm of porous, sintered material. 2. Glass sleeve joint. 3. Contact surfaces between inner and outer solutions.

Another important point regarding reference electrodes is the possibility of refilling them, when the potassium chloride solution has been used up, otherwise the electrode is useless where the inner solution is exhausted.

The potential of a calomel electrode with a saturated solution of potassium chloride as the inner solution is 0.2464 volt at 25°C. against the standard hydrogen electrode.

Automatic *p*H Control System

The electrical circuit of the *p*H cell is characterized by a very low current flow, about 10^{-12} ampères. As recording and regulating instruments are not ordinarily designed to handle such low currents, an amplifier is used to increase the current, the current from the amplifier being passed to the regulating instrument, on which the desired *p*H value is set by a pointer. Another pointer on the instrument moves according to the *p*H variations. When the *p*H value of the solution rises above the desired one the movable pointer, onto which a small plate is fixed, screens to a higher or less degree at a light-sensitive resistance from a light source. Because of this a current begins to flow through the resistance ; this current acts on an electromagnet which raises a slide, thereby causing compressed air to open a valve, through which acid is added to the nickel plating bath. When the *p*H value has decreased to the desired one the movable pointer no longer screens the light-sensitive resistance and no current passes it. The compressed air is hence shut off and no acid passes through the valve. The next time, when the *p*H value is too high, the same procedure is repeated.

(*Continued in page 242*)

Automatic *p*H-regulation of Nickel-plating Solutions

(*Continued from page* 241)

Most of the equipment for the automatic control system is of course delivered from specialized firms. According to the author's experience, however, it is difficult to obtain a valve which is suitable for the regulation of galvanic baths. Certainly there are many valves on the market but they are often too big and too expensive and also unsuitable with regard to the material. As bright nickel-plating solutions are very sensitive to impurities, it is necessary that the valve is not corroded by the acid. Also valves, coated with rubber or resin, may be unsuitable if the filling agents (*e.g.* accelerators or plasticizers) are dissolved in the acid even in minute amounts.

Because of these facts a simple valve, which has a low cost, has been constructed by the author. The valve, which is shown in Fig. 4, is made from a glass syringe, in which there is a thin slit. When the piston, which is operated by the compressed air, is in the lowest position the valve is shut. When the *p*H value in the bath rises and hence the compressed air begins to lift the piston, the valve gradually opens and an increasing amount of acid passes the valve. The maximum flow through the valve described here is 1 litre per minute, which is sufficient even for large plating installations. From the point of view of corrosion, glass is the most suitable material, as it is practically unattacked by the acid. Moreover, as has been pointed out above, the valve is inexpensive. The author has used this type of valve for a long time, and it has functioned without a fault.

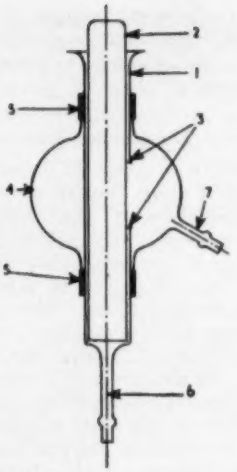


Fig. 4.—*Glass Valve.*
1. *Glass syringe.* 2. *Glass piston.* 3. *Thin slit.* 4. *Glass bulb.* 5. *Rubber joints.* 6. *Acid inlet.* 7. *Acid outlet to the plating bath.*

References

(1) Gray, A. G., Modern Electroplating, John Wiley and Sons, Inc. New York, 1953, pp. 1-5.
(2) Machu, W., Moderne Galvanotechnik, Verlag Chemie, Weinheim 1954, p. 396.

Automatic Plating of Domestic Appliances

(*Continued from page* 238)

is provided by transformers and rectifiers which step down the incoming 400-volt 3-phase supply to 6 to 12 volts d.c.

The automatic plating process entails the immersion of the work in a series of 21 tanks and the sequence is as follows :—

Processes	*Immersion Period.*
1. Hot " Zonax " metal cleaner	2 min. 50 sec.
2. Warm electrolytic " Zonax " metal cleaner	1 „ 10 „
3. Warm swill	1 „ 10 „
4. Cathodic warm Klenewell cleaner	1 „ 10 „
5. Cold swill	1 „ 10 „
6. Cold swill	1 „ 10 „
7. Hydrochloric-acid dip ..	1 „ 10 „
8. Cold swill	1 „ 10 „
9. Flash copper	1 „ 10 „
10. Cold swill	1 „ 10 „
11. Cold swill	1 „ 10 „
12. Cold swill	1 „ 10 „

At this point the operator attaches an internal anode to each kettle for inside nickel plating and a simple device feeds it with current.

13. Bright nickel	15 „	—
14. Cold swill	1 „	10 „

At this point the internal anode is removed.

15. Dilute chromic-acid dip ..	1 „	10 „
16. Bright chrome	4 „	30 „
17. Dragout	1 „	10 „
18. Cold swill	1 „	10 „
19. Neutralizer	1 „	10 „
20. Cold swill	1 „	10 „
21. Hot swill	1 „	10 „
22. Drying oven	6 „	10 „

Push-button controls operate all ancillary equipment, such as pumps and filters, and pilot lights immediately indicate any fault in any part of the system should it occur.

The plating capacity of the Hotpoint factory will be approximately about doubled when the automatic plant is used to full capacity. In addition, because of the uniformity of the automatic processing, the overall quality of finish on the Hotpoint products is even further improved.

The art of Decorating Metals in Various Colours

SOME TYPICAL FORMULATIONS

By E. SCHORE*

AMONG the various duties the electroplater is called upon to perform, none is perhaps more interesting than that of the colouring and bronzing of metals. Until 1828, only one colour of bronze was known to the trade, and this was Verde Antique, of different shades. In the same year the Florentine bronze of *Bronze Lafleur* named after the artist began to appear and a few shops were established to do bronzing for the trade. This was the beginning of the development of the art of bronzing. After the Florentine bronze came the Florentine freme or smoked Florentine bronze ; this was first produced by *Camus* in the year 1933. Next came the Verde Aristique, a kind of pale green relieved on the highlights with yellow bronze powder. This was followed by medal bronze. *Masselotte* was the best artist of this period and was renowned for his peculiar and artistic finishes. Later on appeared iron bronze and still later *Lemoine* introduced smoked bronze. *Crosatier* introduced a kind of smoked bronze on statues made from zinc composition. *Cresson* and *Barye* were also bronzers of note. *Barbedienne* was the originator of a colour of bronze, bearing his name, which is best adapted for statues of larger size. From 1870 and up a series of painted bronzes have made their appearance. These finishes are produced by making fine colours, ground in poppy oil, mixed with bronze powders and a special kind of varnish known as French mission. The figures are first brass plated, then oxidized in a solution of iron oxide and graphite. When the figures are dry, the base, the draperies and sometimes the hair are painted dark and the flesh a lighter colour. In some figures five or six coats are necessary to produce the desired tone. After each coat they are rubbed down with water and rotten stone, and when finished they have the appearance of a solid piece of bronze.

The colouring of metals has been called by various names, among them oxidizing, bronzing, staining, etc., but it is more commonly known as oxidizing. In colouring of metals it should be the aim of the colourist to produce on the surface natural effects as produced by exposure to the atmosphere ; the order in which the colours are formed are first, slight discolourations followed by the browns and blacks to the more antique greens. Any of the shades are useful for ornamental purposes but must be preserved by a coating of lacquer. In the chemical production of colours on metals, the sulphides of potassium, barium, ammonia, arsenic and antimony are the agents most commonly used. The application of a colour on an article is a matter for careful study, in order that the one most appropriate shall be used. The safest rule is to study the motif of the article, and after knowing what the artist had in mind when he designed it, apply the colour that will harmonize with his thought and enhance the beauty and value of the whole.

Typical Formulations for Colouring Metals

Brown on Copper

Water	1 gal.
Sodium thiosulphate (" Hypo ") ...	6 oz.
Nitric acid or lead acetate	4 oz.

Brown on Brass or Copper:

Yellow sulphate of antimony	2 oz.
Caustic soda	6 oz.
Water	1 gal.

Chocolate Bronze on Copper or Brass

Copper sulphate	1½ oz.
Single nickel salt	5 oz.
Potassium chlorate	5 oz.
Water	1 gal.

Warm for copper ; 180°F for brass

Bronzing Solutions

Sodium thiosulphate (" Hypo ") ...	4 oz.
Lead acetate	4 oz.
Washing soda	1 oz.
Water, boiling point	1 gal.

Copper acetate	9½ oz.
Copper sulphate	9½ oz.
Water (boil in a copper kettle) ...	6 gal.

* New York

Copper solution	8 oz.
Ammonium chloride	8 oz.
Water, use hot	1 gal.

Potassium permanganate	1 oz.
Potassium chloride	2 oz.
Water, use hot	1 gal.

Olive Green and Japanese Bronze

Copper acetate	4 oz.
Copper chloride	4 oz.
Ammonium chloride	½ oz.
Water ; use hot water to bring to	1 gal.

Blue Colour Dip on Bronze and Copper

Sodium thiosulphate (" Hypo ")	8 oz.
Lead acetate	4 oz.
Acetic acid	¼ oz.
Water to 180°F.	1 gal.

Barbedienne Bronze on Copper and Brass

Antimony trisulphide	2 oz.
Caustic soda	8 oz.
Water—use hot	1 gal.

Blue Colour

Sodium thiosulphate (" Hypo ")	3 oz.
Lead acetate	3 oz.
Water	1 gal.

Irridescent colours of red, brown and green are obtained by substituting sulphuric acid for the lead salt.

Rainbow Plating

Ammonia	40 gm. per litre
Sodium cyanide	2 gm. per litre
Temperature	70 to 90°C.
Anode	Platinum wire

Japanese Bronze Colour on Copper

Acid copper plate articles for 20 minutes then oxidize in " liver of sulphur " (potassium pentasulphide) until it becomes dark brown, follow this by relieving with pumice stone to make it appear as oxidized copper then immerses in following solution for 2 minutes :

Water	25 gal.
Copper nitrate	7 lb.
Copper acetate	7 lb.
Ammonium chloride	3 lb.

Following this process, sand article and put back in the above solution for 5 minutes. For the second solution take 3 gal. of the first solution and add to 25 gal. of water to be kept at boiling point ; put article in this solution and boil for 10 minutes. Remove and rinse in cold water. Sand until scum is removed, immerse again in the second solution until desired shade is obtained. Rinse in cold water, then in hot water, dry in sawdust, then wipe with a soft rag, and wax with one part of beeswax and one part of carnabra wax dissolved in turpentine, then dry polish with soft rag.

French Bronze on Copper and Brass

Copper sulphate	12 oz.
Sodium chloride	4 oz.
Potassium permanganate	3 oz.
Water—use hot	1 gal.

Olive Green on Brass

Sodium thiosulphate (" Hypo ")	8 oz.
Copper sulphate	4 oz.
Nickel sulphate	3 oz.
Water (use solution boiling hot)	1 gal.

Red Colour on Brass

Copper nitrate	8 oz.
Oxalic acid	8 oz.
Water—use hot	1 gal.

Brown Bronze on Copper

Double nickel salts	10 oz.
Copper sulphate	5 lb.
Copper nitrate	3 oz.
Copper acetate	3 oz.
Water—use hot	15 gal.

Barbedienne Brown on Copper Brass and Bronze

The ingredients used are finely-powdered antimony trisulphide and liquid ammonia ; they are mixed to the consistency of thin paint, and the article to be browned is then dipped into this liquid or it is painted on with a soft hair brush. The ammonia is the ordinary commercial quality and need not be excessively strong. The articles to be treated must be perfectly clean and must have a bright metallic surface. The process is complete as soon as the coating is dry and after the antimony trisulphide has been removed with a bristle brush.

Royal Copper

The royal copper finish for some time past has been attracting considerable attention. When the finish first came on the market, the process of producing it was surrounded with much secrecy and high prices were obtained for the articles treated with it. The royal copper finish can be produced in various ways. One method consists in polishing the goods well and then dipping them successively into potash solution, water and potassium cyanide. They are then washed again in water and are then covered with a thin deposit of lead in a lead bath of ordinary composition. The goods are left about a minute in the bath, using a voltage of 2 to 2½ volts. They are then well rinsed in clean water, care being taken that no solution is left on the articles, as this would produce spots. The goods are then, without drying them, heated in the muffle or with the blowpipe to a

dark red heat. When they show an even red, the heating is stopped and the goods are left to cool off, or they are immersed directly after heating into water. This procedure does not hurt the articles. They are then polished and a proof of the good quality of the oxidation is that the goods can stand strong polishing.

The second method is somewhat simpler but does not show any marked advantages as compared with the first. The well-polished copper articles are painted by means of a brush, as evenly as possible, with a mixture of ordinary oil and lead oxide and then heated as described above. They are then polished as usual.

It is possible to obtain different colours such as brown-yellow, light brown to dark red and stable iridescent colours easily by the following method :

The polished copper articles are first cleaned of all grease by means of potash solution. They are then dipped into potassium cyanide and rinsed off in water. They are then hung as anodes into a bath, which is made up from four parts of litharge (lead oxide) and fifteen parts of caustic potash, dissolved by boiling in 100 parts of water. After all the litharge has been dissolved, the boiling is stopped and the bath is allowed to cool. The clear solution is then syphoned off from the yellow precipitate. The latter has no value and can be thrown away. The bath is now ready for use. As cathodes strips of sheet lead are used, which are connected with the negative pole. The articles to be treated are connected as anodes, as mentioned above. If now a medium current is allowed to pass through the solution, the articles become covered with lead dioxide. This deposit sticks very well to the goods and does not scale off during the subsequent heating and polishing, as happens very frequently when the process of electro-depositing lead upon them is employed. With electrodeposition, especially with larger articles, which have deep recessed areas, it is very often necessary to repeat the process several times, a procedure which takes time, and is also costly. The reason the burnt-in lead deposit scales off so frequently during polishing, especially from the corners and edges of the goods, is due to the peculiar quality of the deposited lead. In general it is quite easy to deposit lead from alkaline solutions and for flat articles a pressure of two volts is sufficient ; but for deep and hollow articles a higher voltage is required. In consequence, the deposit at the edges and corners of the articles which are located opposite to the anodes is apt to be formed too quickly and in a loose powdery condition. This is especially liable to happen before the deep parts of the articles have received a sufficient deposit. This loose deposit is therefore very apt to scale off when the goods are subsequently heated and polished.

If the work on the other hand is carried out in a bath of the composition mentioned above, and with reversed current, the trouble does not arise as the lead dioxide which deposits at the anodes has a much finer structure than the lead deposit obtained at the cathode. The goods which are hung as anodes into the bath become covered, when the conditions of current are right, with iridescent colours (Nobili rings), at first yellow, then green, red violet, and blue and at last brown. The last colour gives an even bright red tone, the true royal copper. The preceding colours can, however, also be burnt in without any trouble and can be used for fancy novelties.

It is possible by experimenting somewhat to obtain colour effects which even surpass the Japanese oxidation effects. Hard-soldered articles and solid brass goods can also be finished in this manner in royal copper, after they have received a sufficiently strong deposit of copper in the acid copper bath. The brass goods are first coppered and then buffed. The best results are obtained in a slightly acid copper bath.

Verde Antique or Verdigris Bronze.

This finish is applied more than any other but it is understood the least ; if properly handled it is beautiful, durable and is appropriate for a large variety of work.

1—*Blue-Green Verdi Patina on Copper or Bronze*

Ammonium carbonate	2½ oz.
Sodium chloride...	¾ oz.
Copper acetate	1 oz.
Potassium hydrogen tartrate	¾ oz.
Water	1 pt.

Oxidize work lightly on a dull finish to a rainbow colour, then brush over quickly with brush in above solution ; after entire surface is covered stipple gently and quickly, keeping entire surface moist while stippling, this stippling brings out the green. Then lay aside and let colour dry gradually ; next day work can be lacquered and waxed. Waxing takes gloss off, and gives it an egg-shell finish on the green.

2—*Yellow-Green Verdi on Bronze*

Vinegar (pure)	2 pt.
Ammonium chloride	¾ oz.
Sodium chloride...	¾ oz.
Aqua ammonia (26 per cent)	½ oz.

The salts are dissolved in the pure vinegar and the ammonia added to the solution. Paint on with brush and stipple same way as instructed for solution 1, then lacquer and wax. If a very quick green is wanted double the salts in above formulae.

3—*Yellow-Green Verdi Green on Copper or Brass*

Copper nitrate	¾ oz.
Ammonium chloride	¾ oz.
Calcium chloride	¾ oz.
Water	6 oz.

This gives a beautiful yellow-green patina on copper or brass. Paint and stipple keeping entire surface moist ; once green appears do not rewet brush, but keep stippling so that the marks come pretty even all over then set aside to dry for at least 6 to 7 hours when work can be lacquered and waxed. (Use beeswax or even an old white candle). This green forms very quickly when stippling. Prepare metal surface as instructed for solution 1 above.

4—*Tiffany Green*

Copper sulphate	8 oz.
Ammonium chloride	4 oz.
Sodium chloride	4 oz.
Zinc chloride	1 oz.
Acetic acid	2 oz.
Water	1 gal.

This above solution requires 2 or 3 coats after each drying. But the author has found a very quick way to bring out the beautiful green with one operation. Prepare the copper very dull and oxidize rainbow colours which appear on the first dip in the " potassium sulphate solution " made weak ; then dry and apply the above mixture, stipple and when it dries it will show just a dark colour with hardly any green. Let it dry for 1 hour and dip quickly in a weak potash (warm wash) just one quick dip, then as quickly in hot water directly, then swing in air to get water marks off and the beautiful green colour will be there. Let dry for about 1 hour then work can be lacquered and waxed. Be sure that metal surface is good and flat so that the green will hold well, as too smooth a surface cannot have anything to hold on to when dry.

5—*Good Green Verdi*

Copper sulphate	16 oz.
Ammonium chloride	15 oz.
Acetic acid	8 oz.
Water	1 gal.

This is good on copper or bronze—prepare work and finish as solution 1.

6—*Green Blue Verdi*

Copper sulphate	2½ oz.
Zinc chloride	½ oz
Ammonium chloride	2½ oz.
Glycerine	¼ oz.
Water	1½ pt.

The glycerine brings out the colour slower and more beautiful as it keeps the metal surface moist and this gives the green longer to form. When dry, lacquer and wax.

7—*Cornflower Blue Verdi Green on Copper*

Water	1 pt.
Copper carbonate	1½ oz.
Ammonium chloride	6 oz.
Ammonia to make solution turn blue	

Take the copper carbonate and mix with water, then add the ammonia until solution turns a deep blue, then add the ammonium chloride last, and stir solution. Let stand for ½-hour. Prepare work with a rainbow colour, dry, then paint over the entire surface quickly and stipple evenly all over then let stand and a beautiful blue-greenish tint forms over surface. Let this colour dry for 2 hours and it can be lacquered and waxed.

N.B. The reason a rainbow colour oxidize is mentioned is because too heavy an oxide coating prevents the green attacking the metal and it will flake off.

Overseas Review

(*Continued from page* 236)

anodizing and performance but relatively little from the metallurgical angle. Fortunately, this omission has now been put right by Howitt and Jenks[5] who report the results of work which shows that aluminium of commercial purity with balanced magnesium and silicon additions or alloys of the aluminium-zinc-magnesium-copper family, all produced within rigid control in the melting and heat-treatment operations gave an excellent combination of low cost, good strength and high reflectivity. The future for aluminium still looks rosy as according to a well-informed source[6] aluminium stands upon the threshold of vast potential applications in the rapidly expanding field of cryogenics! For those like me who are less well informed, this is the generation, transportation and storage of liquified gases.

Essentially Practical

How refreshing it is to read an article which is full of plain common sense regarding cost saving in the finishing departments[7]. I wonder how much money is still wasted by leaving materials in so-called " empty " drums, excessive paint overspray, not dissolving powder chemicals completely in water so that they sink to the bottom of processing tanks and washing machines and how much valuable phosphate is neutralized by carry-over of alkali from previous operations.

References

(1) *Metal Finishing*, 1960, **58**, (4), 52-54, 61.
(2) *Plating*, 1960, **47**, (4), 396-401.
(3) *Plating*, 1960, **47**, (4), 405:411.
(4) *Metal Finishing*, 1960, **58**, (3), 44-47.
(5) *Metal Progress*, 1960, **77**, (1), 87-91, 168, 170, 172, 174.
(6) *Light Metal Age*, 1960, Feb., 6-12, 14-17.
(7) *Ind. Finishing*, 1960, **36**, (4), 39, 40, 42, 44, 46.

B.N.F.M.R.A.

Some Extracts from the Association's Annual Report, 1959

THE year under review was the last of the five years during which Dr. Maurice Cook was Chairman of the Council. A fitting climax to Dr. Cook's term of office was the occupation during the year of the new laboratory block, which completes the original building plan on the Euston Street site. This was opened by Sir Alexander Fleck on May 13, and the opportunity was taken to invite representatives of members to visit the laboratories and to familiarize themselves with the facilities available and the work in progress. Mr. F. C. Braby took over the chairmanship from Dr. Cook in January of this year.

Process Control

Instrumentation

Maximum effort has been concentrated during the latter half of the year on the B.N.F. Plating Gauge for rapid non-destructive thickness testing of electro-deposits. The original instrument, which had proved satisfactory as a laboratory tool, has now been successfully modified so that readings can be taken rapidly by unskilled operators and it is now suitable for industrial quality control.

Further work on the theory of eddy current testing has proceeded and demonstrations of the testing of tubes have been staged. Good progress has also been made in the development of methods of emissivity correction in the measurement of the surface temperature of aluminium during hot-working operations, sufficient to justify attempts to try out the techniques in industrial operations.

End Uses

Corrosion and Protection

Non-ferrous metals owe many of their end uses to their inherent resistance to corrosion, and much of the year's work has been devoted to developing still better alloys for specific purposes, defining the limits of use of known materials, and improving the method of application or the quality of protective coatings such as zinc, nickel or chromium.

Resistance to corrosion by waters is still of major importance. The copper alloys developed to resist corrosion in condensers operating in highly polluted estuarine waters are now undergoing service trials in ships and power stations. A gunmetal developed by the Association for its superior properties in other respects to existing alloys has been shown to be equal to Admiralty gunmetal in resistance to sea-water corrosion.

Many of the researches deal with the use of metals in domestic supply waters. Copper pipes initially free from internal films of either oxide or carbon have been found free from corrosion troubles in all waters except a few soft manganese-bearing waters, where pits may eventually develop after long service. The incidence of such troubles is trifling and this research has been concluded.

No success has been achieved in preventing dezincification of duplex brasses in certain types of water, but good progress has been made during the year in attempts to identify the water compositions which promote this attack. In addition to tests in synthetic waters, efforts are being made in co-operation with the Copper Development Association to obtain failed fittings from many areas to establish the supply waters in which duplex brass fittings can be used without fear of dezincification.

The examination of new types of zinc coating on hot-water tanks is still progressing slowly owing to the difficulty of devising an accelerated test which does not, because of the accelerating agent, produce a type of attack different from that occurring in service and therefore giving misleading results. Installations have been erected in certain districts where the natural water seems to give the right sort of attack relatively rapidly, but quick results cannot be expected.

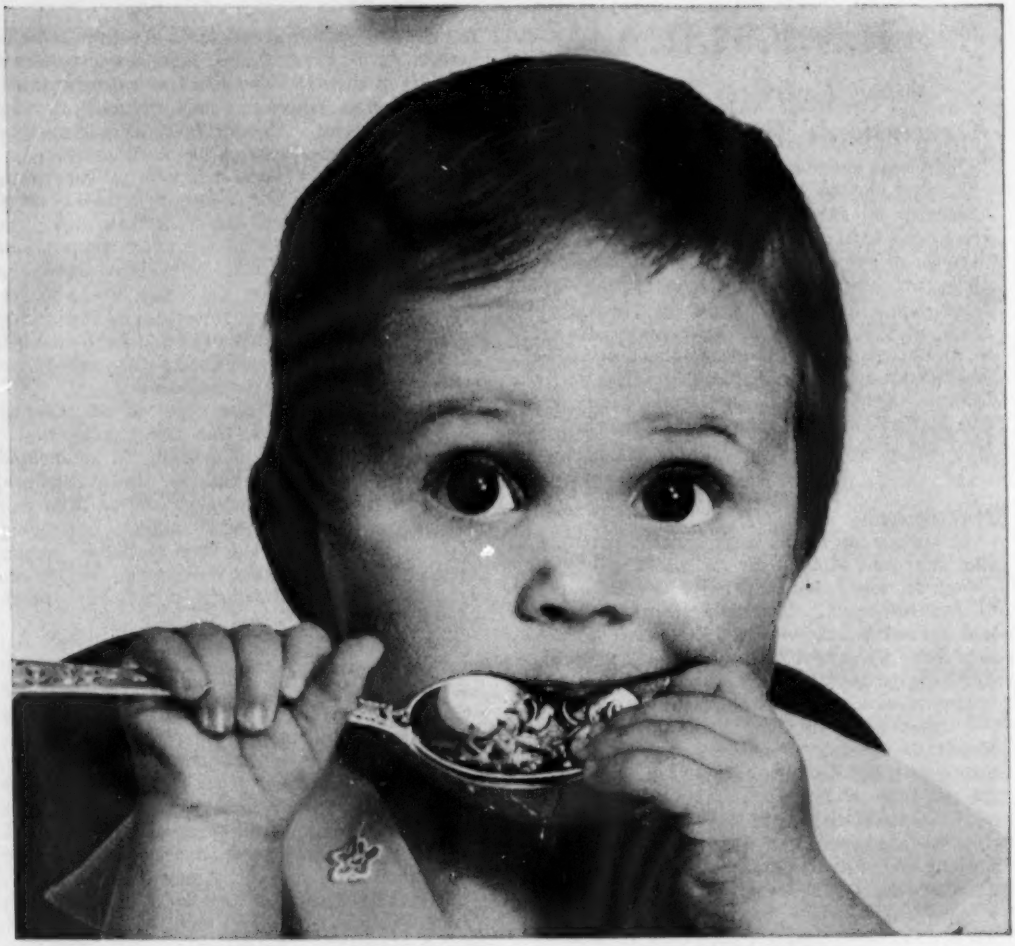
The other line of galvanizing research, the production of heavy coatings on structural steel, has proceeded to the point where conditions for forming coatings in excess of 3 oz. per sq. ft. at all points have been defined.

The use of sprayed aluminium coatings on various alloys has been shown to be of great value in protecting against most forms of corrosion, though there remains some doubt to be cleared up about its complete efficacy against stress corrosion in one or two extremely severe conditions.

The main development in the field of electroplating has been the application of earlier work on conditions for depositing thicker crack-free chromium coatings. The resistance to blistering of nickel-chromium coatings on zinc-alloy die-castings has been shown to be greatly improved by the application of up to 0.00005 in. of chromium, deposited under conditions giving freedom from cracking, on an adequate nickel undercoat (not less than 0.001 in.). In view of the importance of improving quality of these finishes on the zinc-alloy die-castings used on cars, wide publicity has been given to this finding.

The basic study of bright nickel solutions using additions "labelled" with radioactive tracers has made sufficient progress to suggest several lines of future work which may lead to useful practical applications.

One other research in this section has been a comparison with outdoor exposure of the various accelerated corrosion tests available for electro-deposited coatings.



now silver plating

The range of Plusbrite addition agents, already widely known and accepted as the most economical and efficient nickel brighteners, is now extended to include new agents for use in the deposition of silver. New Plusbrite addition agents PB-S1 and PB-S2 now provide a process which deposits a *fully bright* silver directly from the solution. A brilliant and mirror-like surface is produced, eliminating usually any need for buffing after plating. Most existing baths can easily be converted.

Advantages include:

1. Faster plating.
2. Excellent levelling.
3. Bright deposits from a wider current density range.
4. Increased hardness. Ordinary Silver 55DPN—Plusbrite Silver 110DPN.
5. Improved tarnish-resistance.

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ADDITION AGENTS

vmv/338

FINISHING
NEWS REVIEW

"HIGHER NATIONAL COURSE" for Metal Finishers

A THREE-YEAR sandwich course for the Higher National Diploma in Applied Chemistry with Specialisation in Metal Finishing is being arranged at the Borough Polytechnic, Borough Road, London, S.E.1, commencing September 22, 1960, and will be the first and only one of its kind to be held in the United Kingdom with the prime object of giving students a sound scientific background prior to embarking on a detailed study of metal finishing and corrosion science. The minimum qualification for admission is either an Ordinary National Certificate in Chemistry or a General Certificate of Education (Advanced Level) in Chemistry, or satisfactory completion of another comparable public examination. The types of students admissible will be those who are supported independently, those who have scholarships from Local Education Authorities and those who are trainees of firms in different parts of the United Kingdom. The normal fee for students resident in the Administrative County of London is £17 per session and an additional membership fee of £1 1s. 0d. per session. Students residing outside the County of London may qualify for enrolment at the same fee as those resident in London on application to their Local Educational Authority. Applications from the London Area should be made to the Secretary and Clerk to the Governing Body, Fredk. J. Packer, F.C.I.S., A.M.B.I.M., Division of Metal Science, Borough Polytechnic.

Electropolishing and Anodizing used on America-Cup Research Yacht

THE 12-metre yacht *Norsaga*, owned by Lord Craigmyle, is to be used as a control yacht by the Red Duster Syndicate to assist them in their research programme for the building of a challenger for the America Cup. The yacht is to be fitted with a specially designed "Sparlight" racing mast in light alloys with electro-polished stainless steel fittings, manufactured by the Dell Quay Yacht Yard Ltd., Chichester, England. The designer for the syndicate is Mr. Arthur C. Robb, M.B.E. and Mr. P. A. Charlesworth, B.Sc., A.R.I.C., M.Inst.Pet., is the technical consultant.

The mast is claimed to be the most advanced and elegantly designed spar ever made for a 12-metre yacht and will be nearly 100 ft. high. Sparlight spars were fitted on every class-winning ocean racer in 1959 and also on the American 6-metre champion yacht. They are the first spars to have an anodic corundum-hard finish to the light alloys and electro-polished stainless steel fittings. The stainless steel fittings are polished by the "Electropol" process which further increases corrosion resistance.

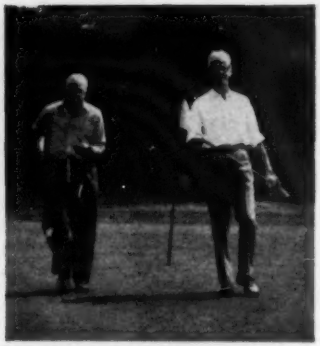
PLATING DEVELOPMENT CONFERENCE

IN their research laboratories in Birmingham, the Mond Nickel Co. Ltd. recently held a plating development meeting which was attended by representatives of the Inco-Mond organization from eight different counties. Those present, who are shown in the photograph given below, were (back row, l. to r.): L. F. Denaro, assistant to sales director; H. C. Castell, development officer U.K.; F. Malavasi, nickel information office, Milan; C. Vollers, nickel information office, Brussels; G. E. Sandland, publicity manager—plating, U.K.; G. N. Flint, head of electroplating research laboratory, Birmingham; K. H. Belcher, nickel information office, Melbourne; F. Dickenson, general manager, Mond Development and Research Department; C. H. Sample, plating supervisor, Inco, New York; Dr. G. L. J. Bailey, Superintendent, Mond research laboratories, Birmingham: (front row, l. to r.): Dr. E. C. Rhodes, manager of general division, Mond Development and Research Department (just out of picture); Dr. W. Parpan, nickel information office, Zurich; J. D. Beddows, Midland area sales manager, Henry Wiggin and Co. Ltd.; L. Arbellot, nickel information office, Paris; Dr. W. Katz, nickel information office, Düsseldorf.

I.M.F. AT GOLF

Successful Meeting at Handsworth on May 30th

A. Jordan and T. Archer



G. Smallwood and H. J. Doughty

THE Golf Section of the Institute of Metal Finishing, under the chairmanship of John Preston (John Preston and Co. Ltd.), met at Handsworth Golf Club, Birmingham, on May 30. Three main awards were competed for, *viz.*, the John Preston Trophy, the Challenor Prize and the Alan Jordan Trophy, and 22 players and visitors enjoyed excellent games on what can only be called a perfect day as regards weather.

The Institute's vice-president, Mr. A. W. Wallbank and Mrs. Wallbank attended, and in presenting the awards Mr. Wallbank stressed the value of social occasions such as this one, and the debt the Institute owed to John Preston for his work in this connexion.

The players were as follows : A. E. Abbott (Wilkes and Godwin) ; T. Archer (Ionic Plating) ; G. F. Bate (William Bate) ; G. W. Bennett A. G. Butler; F. Bulipttand W. Bulpitt (Bulpitt and Sons) ; H. J. Doughty ; H. Horrocks (Bulpitt and Sons) ; C. J. Foote (I.C.I.) ; A. S. Heawood (Verichrome) ; G. Hughes and L. S. Lowery (E.F.CO.) ; J. D. Noble and P. Sanders (E.C.C.) ; W. E. S. Romer (Lepol) ; F. Tubbs (Hockley-kem) ; C. Wharrad and J. Wharrad (Brightachrome), and G. Smallwood and A. Jordan (G. A. Jordan).

The chairman, John Preston, was unable to play due to an injured arm.

Main award winners were as follows :

The Challenor Prize
J. Wharrad
P. Sanders

John Preston Trophy
J. Noble
H. Horrocks

Alan Jordan Trophy
F. Bulpitt
W. E. Romer

W. E. S. Romer and H. Horrocks

Other winners were :

1st 9 medal	T. Archer
1st 9 points	G. F. Bate
2nd 9 Medal	A. S. Heawood
2nd 9 points	W. Bulpitt

The photographs on this page show some of the competitors on this most successful day.

F. Bulpitt and C. J. Foote

A. Jordan and T. Archer

F. Tubbs and G. W. Bennett

IMPROVED PAINT FINISHES FOR BUILDING AND INDUSTRY

BOTH International Paints of Grosvenor Gardens House, London, S.W.1. and Jenson and Nicholson Ltd., of Stratford, London, E.15. claim to have produced a new white enamel paint specially formulated to produce an outstanding initial whiteness which retains its whiteness for long periods without yellowing. The advantage of white is that it not only enhances the value of other colours but has in itself low heat and light absorbtion properties which have an insulating effect on articles and structures to which it is applied, give the effect of a cool outward appearance and if used interiorally affords greater lightness than other colours in effect as well as appearance ; where artificial heat and light are employed, these qualities must result in added efficiency and economy. In addition, experiments and tests in fields of light study indicate that light energy absorbed through the eyes has certain stimulating effects on the human body which is generally borne out by the fact that people are happier and livelier in light and airy surroundings.

Hitherto, however, white paint has shown a tendency to turn dull or yellow after a few months, particularly on interior surfaces not exposed to the bleaching effects of natural light and strong sun, thus not only reducing the general beneficial effects to be obtained but also creating a contrast where white tiling or enamelled articles are present ; this tendency is claimed to be overcome by the introduction of a new medium which it has been found possible only recently to make soluble in paint.

The new name applied by International Paints is Sea Coast Enamel and covers also 48 other colours for which retentive freshness is claimed. Jenson and Nicholson Ltd. have named their new white paint Della Robbia Super White Finish after the Florentine Artist and also report a development in the Industrial Finishes Field with the American paint company — Bradley and Vrooman — which will result in the manufacture in this country of lacquers for cans and special linings for drums used for the chemical and food industries, allowing metal containers to be used for a much wider range of products than hitherto.

DECORATIVE ENAMELS EXHIBITION

THE American enamel artist, Edward Winter of Cleveland, Ohio, has been invited to give a series of illustrated lectures in this country in connexion with the exhibition of his work at the Woodstock Gallery at 16, Woodstock Street, London, W.1, which opened on June 13 and will continue to July 1.

The dates of his illustrated lectures are :—

June 15, 1960: 6.00 p.m.	"Architectural applications of Vitreous Enamel Murals." The Building Centre, Store Street, London, W.1.
June 16, 1960: 2.30 p.m.	"Modern Decorative Enamels." The Royal College of Art, Queens Gate, London, S.W.7.
June 21, 1960: 7.00 p.m.	"Decorative Enamelling Techniques." The Institute of Vitreous Enamellers, Birmingham.
June 29, 1960: 6.00 p.m.	"The Application of Vitreous Enamel to the Decorative Arts." The Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

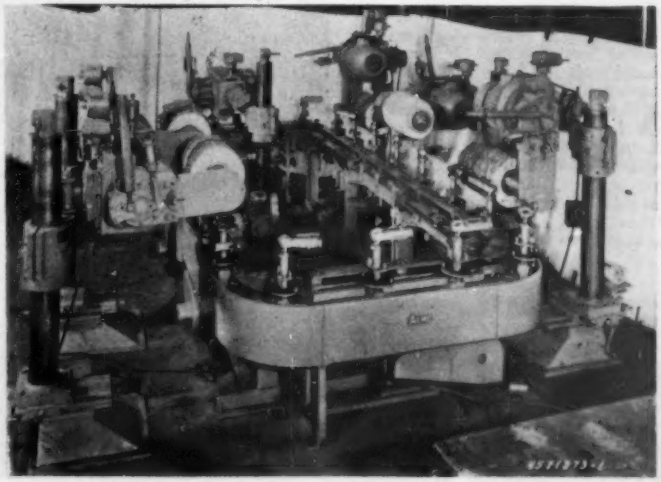
COLD GALVANIZER MODIFIED

A NEW anti-settlement agent has been introduced into Rust-Anode, the anti-rust cold galvanizer made by C. and P. Development Co. of Redhill which reduces the time taken in stirring before application. Tests have been carried out by the makers continuously for nine months and tins of the rust-anode have shown no appreciable settlement after being allowed to stand for over 75 days.

Rust-Anode is a metal coat that is applied to steel surfaces by brushing, spraying or dipping and leaves a coat of pure zinc which is strongly adherant, ageproof and rustproof. Application is simple and can be executed on the site without the necessity of dismantling or skilled labour. It can be applied as an undercoat for paint to provide additional protection, dries to touch within 30 minutes and is dry enough for further treatment after 24 hours. It is non-inflammable and will withstand temperatures up to 400°F. The new additive has no effect on the zinc and the rust-anode dries harder than before.

NEW COMPANY MANUFACTURES POLISHING MACHINES

THE 44-in. perimeter universal open-centre polishing or buffing machine shown below has been produced by Acme-Efco Ltd., Sheerwater, Woking, Surrey, a new company jointly owned by the Acme Manufacturing Co., of Detroit and the Electro-Chemical Engineering Co. Ltd. Acme-Efco Ltd. will be concerned with the sales, manufacture, installation and servicing of automatic polishing and buffing machines in this country. The telephone number of the new company is Woking 5222 and the sales manager is Mr. R. G. Hughes.



PROBLEM OF EXTRUDING SEALING COMPOUND SOLVED

AN interesting extrusion and sealing problem has been solved at Vauxhall Motors Ltd., Luton, by the installation of a series of air-operated Graco pumps mounted on Pneumatic Rams.

The material to be handled was Sealastic, used for the sealing of windscreens, back lights and weather strip assemblies. The problem was to dispense and extrude this heavy material quickly and easily at several points on the paint line.

The material is delivered in open-top drums of 40-gallon capacity as shown below and these are jacketed with Isopad heater units.

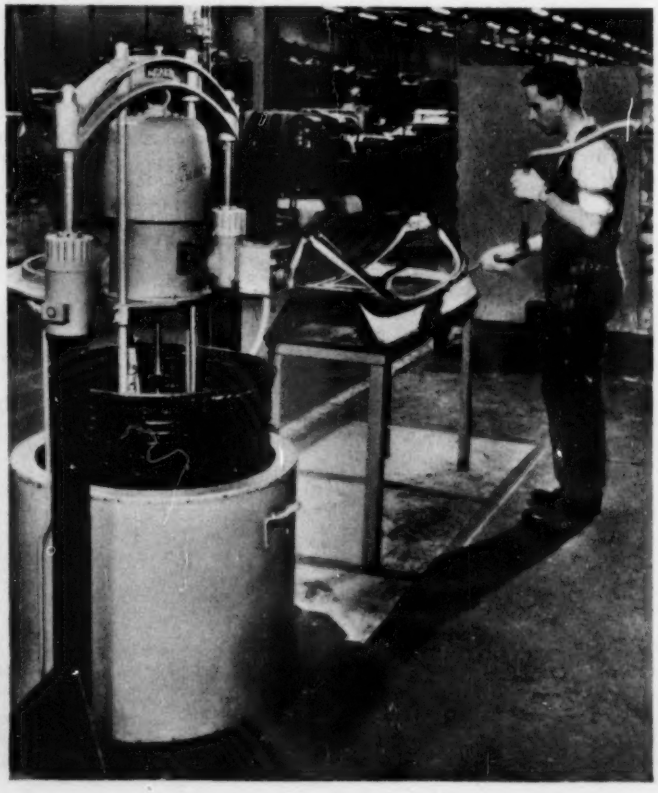
A total of five pumps are used, each mounted on a pneumatic ram. The pumps have a pressure ratio of 40 to 1, so that an air pressure of 75 lb. per sq. in yields a material pressure of 3,000 lb. per sq. in. The material is pumped direct from the drum through ¾ in. bore flexible hose to an overhead steel manifold 1¼ in bore x 30 ft. long. From this manifold, take-off lines are dropped, each comprising 16 ft. of ¾ in hose plus a 6 ft tail piece (½ in bore) to give added flexibility and terminating in an extrusion gun. Four guns are taken off each system, which is independently operated by one pump.

The pneumatic ram, also operating at 75 lb. per sq. in air pressure, is used to elevate the pump when loading and unloading drums, and it also applies a steady pressure to the ram in the drum when pumping takes place.

The system means that a heavier bodied material can be used than would otherwise be possible, and this in turn makes the process both quicker and cleaner. The material can be pumped from the original drum, pumping from the top to obviate aeration and chanelling of the material. The ram seals the material from dirt and scrapes the drum clean, using all the material in the drum.

The installation is thought to be the first of its kind in this country to operate on such a heavy-bodied material.

Sole distribution of Graco equipment for the United Kingdom is through Alfred Bullows and Sons Ltd., Long Street, Walsall.



One of the Graco Pump Assemblies at Vauxhall Motors

FERRO CORPORATION OF AMERICA PLAN EUROPEAN DEVELOPMENT

IT was announced recently by Mr. H. P. Marks, president of Ferro Corporation of Cleveland, Ohio, U.S.A., that Mr. W. R. Todd of Ferro Enamels Ltd., England, had, been appointed to the corporate staff of the parent company — Ferro Corporation — as director of commercial development-foreign. Mr. Todd will be responsible for the immediate drive which Ferro Corporation are making to expand their interests in Europe through the development of new product lines, and the acquisition of other companies which will integrate into the Corporation's existing interests.

Apart from being the world's largest manufacturers of vitreous enamels, Ferro Corporation have, through its domestic and foreign companies, extensive interests in specialized ceramics and refractories, glass fibres, organic chemicals, inorganic colour oxides and electric heating elements.

Mr. Todd has been with Ferro Enamels Ltd. of Wombourn, Wolverhampton, for the past 14 years, during which time he has had extensive experience in most phases of the company's varied interests. He has travelled widely for Ferro abroad, both in promoting business and conducting surveys of foreign markets. For a number of years he was responsible for several operating Divisions of Ferro Enamels Ltd., England, including foreign sales, engineering, plastics, and new product and market development. During recent years, Mr. Todd acted as deputy to the managing director and joined the board of Ferro Enamels Ltd. last October. He retains his seat on the Board with his new appointment.

Government Sponsored Apprentice Schemes

THE Minister of Labour, Mr. Edward Heath, has announced that he proposes to set up a small number of classes in Government Training Centres to provide first year apprenticeship training for boys accepted as apprentices by firms and preferably from firms which have hitherto found it impracticable to undertake apprentice training or to increase their present number of apprentices. No charge will be made for the training provided but employers taking part in the scheme will be required to give an undertaking to pay the wages of apprentices during the year and to continue the boys' training afterwards under the normal industrial arrangements. The usual provision for day release will apply during the year. The scheme has been approved as a whole by the British Employers' Confederation and the Trade Union Congress, and the establishment of classes in engineering has been agreed by employers and trade unions in that industry.

The first training places will be available this summer at 8 Government Training Centres — Aintree, Birmingham, Bristol, Cardiff, Hillington, Leeds, Letchworth and Long Eaton. Further classes will be added at some of these centres and at others, probably Enfield, Leicester, Perivale, Slough and Waddon.

Training will cover, on a systematic basis, a syllabus similar to that covered during the first year by firms with good apprenticeship training arrangements. Detailed syllabuses have been supplied to the engineering and construction industries.

WATER SOFTENING BY ELECTRIC MEMBRANE PROCESS

A NEW portable water-softening unit, which is claimed to be 500 times more efficient than comparable electrical devices, was described recently to the American Chemical Society by its inventor, Dr. Joseph A. Schufle, chemistry professor at the New Mexico Institute of Mining and Technology. The unit removes salts and other impurities from hard water at the rate of 2 gallons per hour on 10 watts of electricity, while an electric still with equivalent capacity would require 5,000 watts; higher voltages increase the production capacity of the device which can be attached directly to the water line.

Water of distilled quality, containing no more than 5 parts of impurities per million parts of water, have been obtained from city water in Socorro, N.M., where the impurity rate had been 155 parts per million, by the employment of this apparatus. The unit, which measures 12 in. by 12 in. by 20 in., works by an electric membrane process; it imparts an electric impulse to water thus forcing ions (electrically charged particles of impurities) into a porous membrane; once captured, the ions are discharged in a small waste stream, leaving the water "deionized" or soft.

Voltages of 250, 350 and 450 d.c. have been used successfully in the membrane cell with corresponding increases in the rate of production of deionized water; it works at room temperature and does not give off large amounts of excess heat as is the case with distilling apparatus.

Analysis Equipment for Metallurgical Research

IN modern industry, quality control is an integral part of progress and the metallurgical industry is one of the most exacting in this respect. The increasingly high standards demanded necessitate new and more precise techniques of quality measurement and more specialised and accurate devices to arrive at such measurements.

Over the past thirty years the policy of The Mond Nickel Co. has been to devote a large part of its energies and expenditure in the maintenance of a highly organized development and research service. The company's Birmingham Laboratory is probably the largest and best equipped research organisation in its field in Europe and the acquisition of new and up-to-date equipment is a high priority.

In June last year, the Department took delivery of one of the first models of a new automatic X-ray fluorescence spectrometer, manufactured by Solartron, which carries out non-destructively precisemeasurement of the constituents of an alloy exceeding 0.1 per cent.

More recently, a solids mass spectrometer, the first commercially produced machine of its kind in the world, has been installed. This equipment, supplied by Metropolitan-Vickers, analyses for all elements in the Periodic Table down to one part in 100 million.

These two instruments together provide a unique combination of sensitive and accurate analysis over a wide range of compositions.

IMPROVED METHOD OF BONDING PLASTIC TO COPPER

A CHEMICAL method of coating copper with plastic, of particular value for sealing transoceanic cables, was described recently at the American Chemical Society's 137th national meeting by Dr. Arthur Spencer and Richard G. Baker of the Bell Telephone Laboratories, Murray Hill, N.J.

Hitherto, the inability to form load-bearing bonds to polyethylene has prevented its use in many structural applications and the main reason is that its slippery surface, which is chemically very inert and resistant and makes it very desirable for many applications, provides no site for an adhesive material to grip and resultant adhesive bonds are weak.

The new method provides grippers on the polyethylene plastic which cling to the copper, eliminating the need for adhesives. High temperatures are used to oxidize the polyethylene during which process the plastic accepts some of the oxygen present on the copper and in doing so forms grippers that cling tenaciously to the oxygen remaining on the copper; the resultant bond has a strength value several times that obtained by other methods and, in tests, bonds thus formed have failed only through the tearing of the polyethylene rather than the failure of the bond itself.

High bond strengths have been achieved by the process between a wide range of polyethylenes and copper alloys containing at least 85 per cent. copper.

Well-Known Silversmiths Change Name

TO conform with their policy of using a name common to its operations in every part of the world, the Kenwood Silver Co. Ltd. of Eckington, Sheffield, changed their name to Oneida Silversmiths Ltd. recently. The company are makers of Community Plate and Tudor Plate but they are expanding their activities which involves a considerable increase in the whole of their organization and strengthening their board.

NEW COMPANIES

" Ltd " is understood, also " Private Co." Figures = Capital, Names = Directors, all unless otherwise indicated.

Delta (Plant), 56, Victoria Street, S.W.1. February 19. £150. To carry on bus. of crane and metal workers, refiners, manufacturers, agents, exporters, importers and repairers of articles wherein metal forms all or some part, etc. Gerald R. V. Briere, Josjane J. A. Briere.

Metal Vibration Development, 52/4, High Holborn, W.C.1. February 25. £5,000. Stephan D. Lee, David Duncan, Peter J. Price, Chas. M. George.

Airs Plating and Engineering, 107, High Street, South Benfleet. February 26. £5,000. Alfred F. J. Airs, Ronald H. Downing, Percy J. Thompson.

Prefinished Stainless Steels, 275, Ecclesall Road, Sheffield 11. March 3. £100. Peter D. Hall, Frank Tomlinson, Herbert Shulson.

Wests-Loyne, Drewitt Street, Miles Platting, Manchester. March 11. £25,000. To undertake all operations in connection with the application of linings and coatings of anti-corrodable and anti-corrosive substances, etc. Directors not named.

Brownshills Polishing, Anglesey Works, Watling Street, Brownhills, nr. Walsall. March 14. £2,000. To carry on the bus. of metal polishers and light industrial metal works, etc. Directors to be appointed.

J. A. Stokes, 40/42 Portland Street, Walsall. March 23. £10,000. To carry on the bus. of electro-platers, stove enamellers, metal sprayers, finishers, polishers, etc. James A. Stokes, Alfred M. Osborne.

J. J. Plating, 63 Hendrecafn Road, Tonypandy, Glam. March 29. £1,300. To carry on bus. of electro-platers, etc. Thomas J. Bowen, David J. Davies.

Colourite, 77 Portland Place, W.1. April 6. £100. To carry on bus. of anodizing process engineers, etc. Alice S. Linsell.

Frederick Feldmann, 3 Oxford Street, W.1. April 7. £1,000. To carry on business of consultants on all metallurgical processes, and as manfg. chemists, ironfounders etc. Fritz Feldmann and Mrs. L. F. H. Feldmann.

From the Register compiled by Jordan & Sons Ltd 16 Chancery Lane, London, W.C.2.

TECHNICAL *and* INDUSTRIAL APPOINTMENTS

Philip E. Neff, has been appointed assistant to the president of **The O. Hommel Co.,** Pittsburgh ceramic supplier. Mr. Neff has had wide experience in both sales and manufacturing, and in his new position will assist Mr. Hommel in the administration of plant and promotional sales activities. Before coming to Hommel, Mr. Neff was plant manager of Stoner-Mudge Co., well known protective coatings manufacturers and prior to that was in the sales promotion work with Rohm and Haas Co. and also served as vice-president of Hood Chemical Co. in Philadelphia.

* * *

Cellon Ltd. announce the decision of Mr. W. F. Wilson to retire from the Board upon his acceptance of the appointment as consultant to the group. During his 35 years with the company, he has made many friends on both the consumer and production sides of the finishing industry, with whom he hopes to maintain contact.

* * *

Mr. F. A. S. Wood has been elected chairman of the **Croda Organization** to succeed the late Sir Edward Crowe, K.C.M.G. and also retains his post of managing director of the company. Mr. Norman Townend, F.C.A., has also been elected a director of the company.

* * *

Brigadier H. P. Crosland, C.B., C.B.E., M.C., T.D., D.L., chairman and managing director of Metal Traders Ltd. has been elected chairman of the **Zinc Development Association** for 1960. The former chairman, Mr. R. T. de Poix, O.B.E., will continue as a member of the council of the Association.

P. E. Neff

* * *

Mr. R. E. Powell, former president for 20 years of **Aluminum Co. of Canada, Ltd.,** the principal subsidiary of **Aluminium Ltd.,** has resigned as a senior vice-president of Aluminium Ltd., and was named honorary chairman of Aluminum of Canada Ltd. Mr. Powell, who has served 50 years in the industry, remains a director of Aluminium Ltd. and Alcan. Mr. Edwin J. Me ia, chief sales management officer, was appointed a senior vice-president of Aluminium Ltd.

ENGINEERS PUBLISH HANDBOOK

THE 1960 edition of the British Engineers' Association Classified Handbook of Members is now available. The Handbook (608 pages) includes a comprehensive list of members products classified alphabetically under more than 3,000 product headings, so arranged as to be of the maximum assistance to purchasers of engineering equipment. The classified index is repeated in French, German, Portugese and Spanish. The Handbook also includes an index of Trade Names and Trade Marks.

Copies of the Handbook are being sent, free of charge, to selected buyers of engineering equipment in every country in the world which has business with the British engineering industry ; it may be purchased from the B.E.A. price 21/-.

BRITISH NON-FERROUS METALS AND Z.D.A. JOINT SYMPOSIUM

THE British Non-Ferrous Metals Research Association, in collaboration with the Zinc Development Association is organizing an afternoon symposium at the Botanical Gardens, Edgbaston, Birmingham, on Wednesday, June 29, 1960, to discuss the results of recent research work designed to improve the durability of nickel-chromium plating on zinc-alloy die-castings. This symposium is open to anyone interested in plated die-castings, whether as users, manufacturers or metal finishers. Tickets of admission are obtainable on application to The British Non-Ferrous Metals Association at Euston Street, London, N.W.1.

Trade and Technical Publications

A new paper of 6 pages describing metallurgical properties, operational data, and uses of a patented acid-type industrial gold electroplating formulation, trademarked Autronex, is offered by Sel-Rex Corporation, Nutley, New Jersey, U.S.A.

The technical exposition covers in detail the composition of this low-*p*H gold formulation for industrial applications, deposit characteristics, corrosion resistance, equipment requirements, solution makeup and maintenance, gold consumption, trouble shooting, analytical procedures and metal content chart.

Autronex gold, which is claimed to produce tarnish-free deposits to any desired practical thickness, is being used by industry in applications ranging from electronics (printed circuits, transistors, connectors) to castings and satellites. The booklet, AG-2, is free on request.

* * *

Midland Silicones Ltd., have recently published a well-illustrated technical booklet describing the engineering applications of their range of silicone fluids. Almost unknown a few years ago, silicone fluids have won a reputation in the last few years as one of the more interesting and useful of the newer materials available to engineers. Mechanical devices, until recently considered quite impracticable, have been successfully developed using silicone fluids. Among established applications, silicone fluids are already well known in damping devices, liquid springs, fluid couplings, and hydraulic power transmission units.

The booklet 'Engineering Guide to MS Silicone Fluids,' emphasizes that silicone fluids are outstanding for their exceptional thermal stability and resistance to oxidation. All these fluids show a remarkably small change in viscosity with temperature and resist breakdown due to shear. They are water repellent and retain good dielectric characteristics over a wide range of temperatures and frequencies. Amongst the other desirable properties the silicone fluids exhibit are included low volatility, low freezing point, high flash point and incompatility with organic oils and polymers. The booklet has many charts and tables.

The booklet is available from Midland Silicones Ltd., Head Sales Office, 68 Knightsbridge, London, S.W.1.

The Gas Council, 1 Grosvenor Place, London, S.W.1., have issued an eight-page, two-colour booklet giving factual information about the industrial therm in simple language. Examples of the use of gas include the heat treatment of metals, metal melting, galvanizing, drying and finishing. The booklet should be of particular interest to school-children.

* * *

B.S.I. News for April, issued by the British Standards Institution of 2 Park Street, London, W.1, refers to a Special Issue—B.S. 1224; 1959, "Electroplated coatings of nickel and chromium," consisting of a working drawing of the B.N.F. sulphur dioxide corrosion test cabinet. Copies of the drawings can now be obtained, price 5s.

* * *

The Liverpool Borax Co. Ltd., Maxwell House, St. Paul's Square, Liverpool 3, have issued an illustrated folder, "Volvite," describing the various applications for Volvite—the trade name for a range of balanced formulations in the alkali, acid and surfactant groups in both powder and liquid form, scientifically designed and manufactured under constant laboratory control in varying degrees of potency to meet the requirements of every branch of industry, including degreasing, cleaning, descaling, burnishing, electroplating, paint and print removing and wherever chemically clean surfaces are required.

* * *

The Hanson-Van Winkle-Munning Co. of Church Street, Matawan, N.J., have published a new bulletin, "No. A.C.-112," describing and illustrating a full line of H-VW-M anodes, anode accessories and chemicals for electroplating and metal finishing. Specifications and recommended applications are given for several styles of anode bags and seven types of anodes. The bulletin lists salts commonly used in electro-plating baths and a number of brighteners used in H-VW-M solutions. Standard package sizes are shown for these products.

Anodes described include nickel, cadmium, brass and bronze, copper, lead and zinc. Various types of nickel anodes are listed along with recommended applications and pH ranges. A page of line drawings tells how to order hooks for round, flat and shaped lead anodes.

VITREOUS-ENAMELLED STEEL AT MILAN TRIENNALE

THE main feature of Britain's contribution to the Milan Triennale, which takes place from July to November this year, is a typical English school designed by the Architect to the Nottinghamshire County Council, Mr. W. D. Lacey, A.R.I.B.A., A.M.T.P.I.

The infill panels chosen for this school—as for many other schools in Britain—are "Curran Seaporclad" vitreous-enamelled steel panels, manufactured by Edward Curran Engineering Ltd., of Cardiff.

To cover a required 400 square feet, 66 panels of various sizes have been supplied. Each consists of a flat 16-gauge steel sheet, vitreous enamelled in a semi-matt finish in B.S. 9-098 (dark blue) and bonded to a fibre board to provide a laminated panel having a "U" factor of approximately 0.3.

At the close of the Triennale, the school will be presented to the Italian nation, to be dismantled and re-erected at a chosen site.

ENAMELLERS VISIT WATSON HOUSE

LAST month, the southern section of the Institute of Vitreous Enamellers, organized a visit to Watson House, the centre for all the Gas Boards testing programmes. Members, their ladies and guests were invited to join in what proved to be a most interesting and instructive visit.

The tour included the inspection of the various laboratories where the Board test the numerous appliances that operate with gas, and a number of cookers and refrigerators were seen actually undergoing these tests. Particular emphasis was placed on the durability of vitreous enamel and the use of gas during enamelling processes. Discussion of the problems experienced by the Board took place, and proved similar to those experienced by the enamellers themselves and some of the solutions to the maior problem of packaging and transportation of vitreous enamel were seen.

An excellent tea was provided by the hosts, the North Thames Gas Board, who endorsed the view of everyone present, that these visits are an extremely pleasant way of hearing the other side of the story.

Latest Developments in PLANT, PROCESSES AND EQUIPMENT

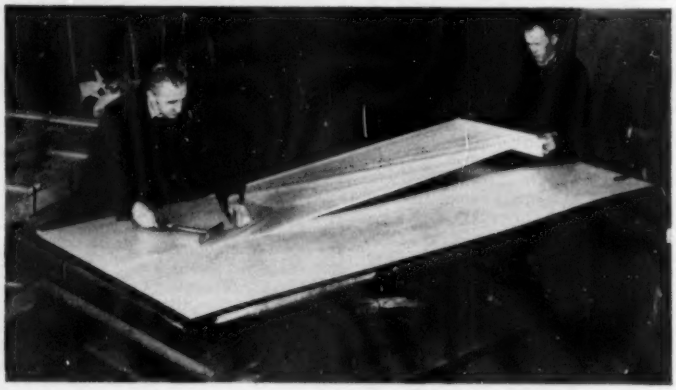


Fig. 1—Application of protective paper tape

Protective Paper Tape

A LOW-adhesion paper tape for protection of polished stainless steel or other highly finished surfaces during fabrication or in transit, has been produced by Permacel Tapes Ltd., 260 Bath Road, Slough, Bucks.

Permacel 95 protective paper tape is a thin yet exceptionally strong paper tape with a low-tack, non-staining pressure-sensitive adhesive designed specifically for protecting various types of polished surface. It gives maximum protection to stainless steel, aluminium, or plated components during forming, bending, fabrication and shipment, is resistant to abrasion and gives adequate adhesion to even the most highly polished surface, yet when removal is desired strips cleanly.

Fig. 1 shows the ease with which the paper is applied.

Aerosols for Spray Painting and Lubrication

DCMC of 2a, Parkhurst Road, London, N.7 are now marketing colour-coding paints in a range of 10 colours, packed in 16-oz. aerosol containers using a special paint formulation, with exceptional adhesion, which can be applied to metals, wood and plastics under a wide range of difficult conditions and enable colour coding under A.I.D. and B.S.I. standards to be performed easily without the operator carrying several brushes and paint pots.

Other DCMC products include silcone mould release, cutting oil, degreaser, rust inhibitor, lubricating oil, gear and chain lubricant, penetrating oil, all-purpose solvent and clear lacquer.

Sound-Deadening

A NEW method of sound-deadening light-gauge sheet-metal has been evolved by Supra Chemicals and Paints Ltd.

The new material—Dedshete—is manufactured in flat sheet and is claimed to impart a far higher rate of sound " decay " than any other material tested, and it ensures very efficient suppression of drumming and " tinniness " in sheet metal fabrications.

The material is self-adhering, and requires no pre-fixing or taping in position ; it is simply placed on the metal and stoved for five minutes at 300°F. during which time it moulds itself to, and adheres to any contour. Adhesion is permanent, and it can be restoved at temperatures up to 350°F. without adverse effect. No prior degreasing of the metal is necessary, for Dedshete adheres readily to any reasonably clean surface and even to stock-oiled sheet.

Two all-important aspects of this new material are the elimination of waste, and the exceptionally low cost of application. Dedshete can be supplied cut to any size or shape within the limits of 42 in. by 30 in. thus ensuring that any defined area is covered to a uniform thickness. As brushing, spraying and pre-fixing are eliminated there should also be an exceptionally high saving in labour costs.

Technical literature and samples of the material are available from the patentees and manufacturers, Supra Chemicals and Paints Ltd., Hainge Road, Tividale, Tipton, Staffs.

(*Continued in page* 257)

Plastic-Coating Materials

THE latest American plastisol plastic-coating materials developed by Metal and Thermit Corporation under their trademark Unichrome are now available in this country. They can be applied to all metals to form a rough resilient coating which, it is claimed, stands up to the most severely corrosive acids, strong alkalis and many other chemicals. They are highly abrasion- and scratch-resistant, shock absorbent and sound deadening. They have high electrical insulating properties (up to 400 or 500 volts per thou. thickness) and good heat-insulation.

The formulation No. 5300 Super is for spray application. Thicknesses of up to 0.04 to 0.06 in. can be applied in one coat even on cold vertical surfaces without sagging or building up. Multiple coats can be applied without lamination to build up to thicknesses over 0.06 in. It is said to give a smooth uniform deposit even on sharp edges, free from pores and pinholes. Due to the fact that the material does not contain any solvents, the dry coating after baking will have almost the same thickness as the wet coating. Short baking at 355 or 365°F. is required for the curing of the coating. It can also be applied electrostatically.

Another formulation, No. 4129, is a cold dip plastisol only suitable for wirework. It can be applied in many cases without a primer. Withdrawal rates up to 15 in. per minute have been achieved. There are said to be no drips and, after withdrawal, immediate baking is possible as no draining is required. Thicknesses of 10 per cent of the diameter of the wire can be obtained in one dip. Conveyorized dipping methods can be used. Some examples of its application are as follows : refrigerator shelves, dish washing racks, baskets of all types and all other types of wirework.

Both of the foregoing materials are available in many attractive colours. In addition, two other types available are 5300 H giving a coating which is harder and more matt than that produced by 5300 Super, and B6 giving a crackle effect specially suitable for finishing adding machines, duplicating machines, etc. A primer 219 PX is supplied as a white creamy material especially developed to give the various plastisol coatings perfect adhesion.

Further details can be obtained from M. L. Alkan Ltd., Stonefield Way, Victoria Road, Ruislip, Middlesex (Ruislip 3300).

Flexible Hose

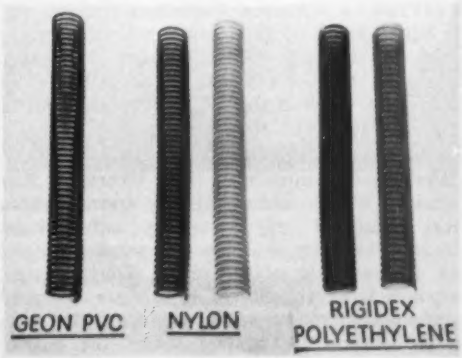
A RANGE of hoses with the trade name of Vacuflex has been developed by Creators Ltd. by a new process. Having had previous experience in developing and patenting a machine capable of producing steel spring hose on a continuous basis, a special development team was employed on improving the basis principle and evolved a machine having a capacity of from 1 in. to 4 in. bore in lengths of 100 ft. or even 200 ft. A new company was formed, Recon (Pipelines) Ltd., with the object of manufacturing and distributing a whole range of piping in Great Britain. The original conception was for a polyvinyl chloride vacuum cleaner hose but further types that have been developed by Recon include rigid pipes and pipes made of nylon, high density polyethylene, rigid p.v.c., polypropylene and other materials ; pipes reinforced with steel spring wire and with nylon filaments are now in production and they can also be reinforced with rayon, cotton and even wire mesh.

Some of the rigid pipes have such a low density that they can float on water and can withstand boiling water for many hours. Among the many applications for which they are suitable in industry are steam exhausts, chemical fume extraction plants, air lines and for machinery where the pipe is not only stationary but where it also oscillates with a moving part of the machine.

Among the characteristics of the new rigid pipes is their lightness in weight and consequent ease of manipulation, and their ability to withstand very high pressures ; although they are anti-crush and can stand a man's weight, they can be bent around their own diameter by applying a draught of hot air. In general, temperatures between 10°C. and 80°C. are suitable for both flexible and rigid pipes and temperatures above and below these temperatures may be permissible where no mechanical function is required.

The address from which further information can be obtained is Albert Drive, Sheerwater, Woking, Surrey.

Fig. 2.—Samples of flexible hose, made from materials chosen to give optimum performance over a wide range of conditions.



Oil-Resisting Finish

ARMOUR 1172 has recently been introduced by Griffiths Bros. and Co. (London) Ltd. (Armour Works, Well Lane, Wednesfield, Staffs). Oil and heat resisting, the product is an air-drying gloss finish claimed to be resistant to transformer, lubricating, diesel and certain cutting oils. Suitable for exterior exposure, it is also said to be resistant to mildly acidic or alkaline conditions and to be able to withstand temperatures up to 140°C.

Its main applications are in the engineering industry, where it is suitable as a coating for sumps, the interior of transformer tanks, and the exterior surface of petrol tanks. But it is also suitable for use wherever a rapid drying gloss finish with rapid set is required. It is capable of being force dried, which is said to enhance the gloss.

Available in black and 631 light battleship grey, application is by brush dip or spray, direct on clean metal. It touch-dries in 20 min. and hard dries in 2 hr. or in a shorter time if force dried.

Powder for Dip-Coating

THE Plastics Division of The Telegraph Construction and Maintenance Co. Ltd. at Farnborough, Kent has now introduced Telcovin 'A' (p.v.c.) powder as an addition to their range of thermoplastic powders for dip-coating, which already includes Telcothene (polythene, high or low density) and cellulose aceto-butyrate.

Telcovin 'A' provides a tough yet flexible finish with good resistance to inorganic chemicals and mineral oils, and enables powder dip-coating to be employed as an effective alternative to the current method of coating with p.v.c. plastisols. Among the advantages of the powder, which can be used with all existing types of fluidizing equipment, are speed of processing and elimination of the wastage and inconvenience caused by drips.

Metal Degreasing Plants

IMPERIAL Chemical Industries Ltd., of Millbank, London, S.W.1 are now marketing a series of ultrasonic cleaning plants designed for use with trichloroethylene. The smallest and simplest of these is the ULVI (compartment size 9 in. by 7 in. deep), shown in Fig. 3.

Ultrasonic generating equipment, made by Dawe Instruments Ltd., 99 Uxbridge Road, London, W.5, is connected to a sealed stainless-steel transducer unit containing barium-titanate elements submerged in cool trichloroethylene in one compartment of the plant. Here, electrical impulses at a frequency of 40 kc/s are changed to mechanical vibrations which produce " cavitation " in the solvent. Cavitation means the alternate formation and violent collapse, at a very high rate of minute cavities in the liquid, giving an intense scouring action at the surfaces of the work. The high solvent power of trichloroethylene on oil and grease contamination is assisted by the mechanical effect of the scouring, so that insoluble solid particles are effectively detached, even from cracks and pits on metal surfaces. The solvent in the ultrasonic cleaning compartment is circulated by a pump through a filter, where solids are collected, and back to the same compartment. The filter is easily accessible for renewal.

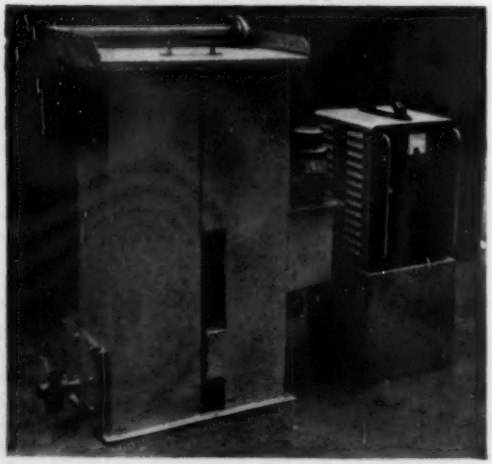
The other compartment in the plant holds electrically heated boiling trichloroethylene below a vapour layer. Vapour rises to the condensing coils, falls as liquid into the ultrasonic compartment and returns to the boiling liquor compartment by over-flowing the weir plate. A water coil prevents the temperature in the ultrasonic compartment from rising above 60°C. and damaging the transducers.

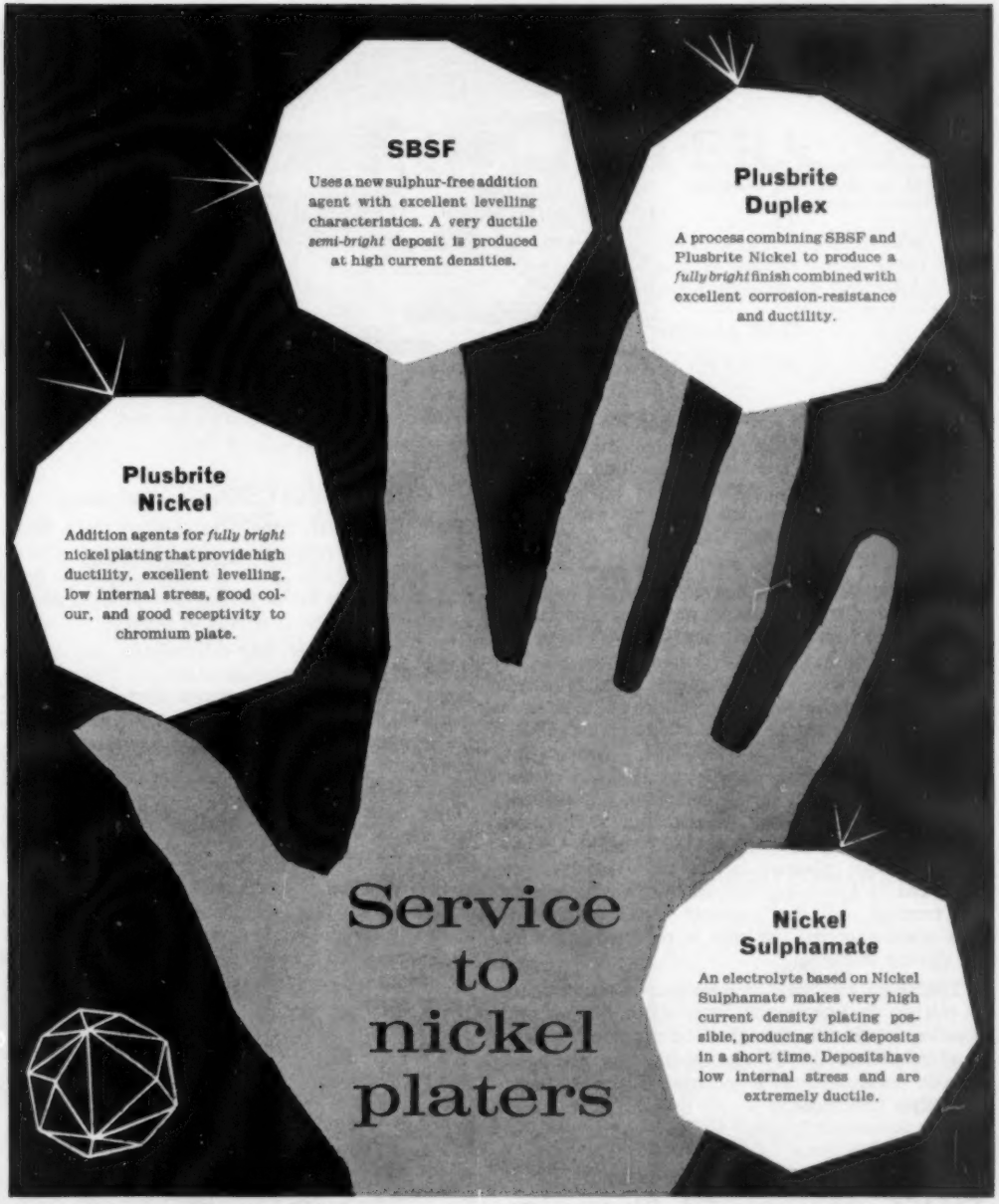
The route of articles through the plant varies according to their condition. Most of the work for which the ULVI is appropriate is not heavily greased or oiled and can go straight into the ultrasonic cleaning compartment, and then into the vapour above the boiling liquor. Grossly contaminated work should be given a preliminary dip in boiling liquor ; in the larger plants three compartments are provided so that a steady flow of work can be maintained. The final immersion in vapour is desirable for safety and economy, as it ensures that work is dry when it leaves the plant.

Safety features include rim ventilation equipment and a thermostat which cuts off the heat if the water fails or if the solvent level falls too low.

(*Continued in page* 260)

Fig 3.—*Metal degreasing plant*

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TBW/687

Fig. 4.—The Mag-ray gauge manufactured by the Boeing Airplane Co. Wichita, Kansas, U.S.A.

Plating Thickness Gauge

A NEW gauge for measuring thickness of metal plating and so sensitive that it can be calibrated to indicate differences of one-millionth of an inch has been developed by the Boeing Airplane, Co., Wichita, Kansas, U.S.A., (Aero-Space Division). (Fig. 4).

The new gauge is actually two gauges in one ; one portion of the instrument measures capacitance changes, the other the intensity of beta-ray reflection. From this combination the device has been named a Mag-ray gauge. The thickness of a ferromagnetic plating, such as nickel, is measured through the use of magnetic force. A magnet attached to a small spring deflects the spring when the magnet is placed close to the nickel plating. The spring deflection is measured by a capacitance meter which, after calibration, indicates the thickness of the plating. Non-ferromagnetic platings such as rhodium are measured by a beta-ray technique wherein the rays are focused on the material to be measured. The amount of the ray that is reflected indicates the plating thickness.

The gauge was developed for such measurements as plating thicknesses on timer discs for Bomarc missiles, in which both nickel and rhodium platings must be measured. Future applications envisaged include measurement of ceramic coatings, paint and other thin skins.

Heavy Duty Angle Grinder

BLACK and Decker Ltd., Harmonsworth, Middlesex, have produced a new heavy-duty angle grinder which can be adapted for use with 7-in. and 9-in. sanding discs, saucer grinding wheels, wire cup brushes or planer heads, (Fig. 5). Switch and bearings are sealed against dust and dirt and it is claimed that even after 540 hours without servicing, the machine is clean internally.

The overall length, without pad, is $18\frac{3}{16}$ in. and the net weight is 14 lb.

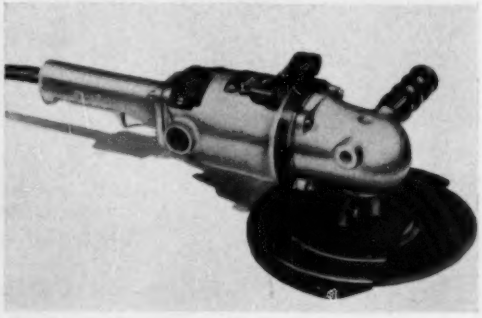
Nickel and Cadmium Stripping

ROTO Finish Ltd., Hemel Hempstead, Herts., have introduced a new stripping solution, "Niplex" which, it is claimed, removes nickel and cadmium without pitting or corroding the base metal, even where it is zinc or copper.

The solution is non-electrolytic and can be operated cold, or heated up to 80°C. The stripping rate of a fresh bath at room temperature is approximately 0.00025 in. of nickel per hour, but this can be accelerated by heating the solution up to a maximum of 80°C. when the stripping rate is increased to 0.003 in. per hour. Using a special dilute bath at boiling temperature the stripping rate can be further increased to 0.006 to 0.009 in. per hour.

The solution contains no cyanide, caustic or acid, does not fume and is stable for long periods in use or standing. It is claimed further that it is so balanced chemically that all the components are exhausted at the same time and in normal use no analytical control is necessary.

Fig. 5.—Black and Decker heavy-duty angle grinder



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One representative, who will work from Gidea Park, required to cover the Greater London Area and the South of England, and one who will be based in Birmingham, to cover the rest of the country. Salary and commission, company car provided.

Application form obtainable from the Personnel Manager, Lacrinoid Products, Stafford Avenue, Gidea Park, Essex.

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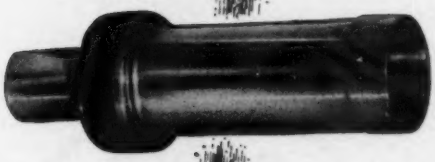
Applications, containing details of qualifications and experience, should be submitted in writing to Personnel Manager, Imperial Smelting Corporation Ltd., St. Andrew's Road, Avonmouth, Bristol, quoting ref: MTF/MFJ.



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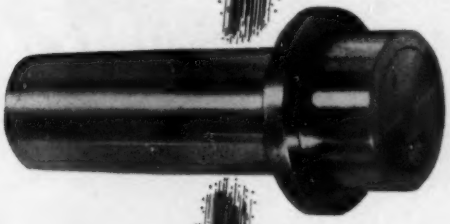

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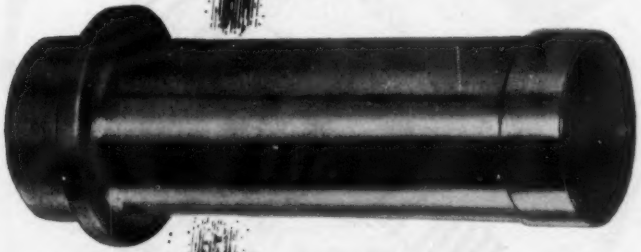

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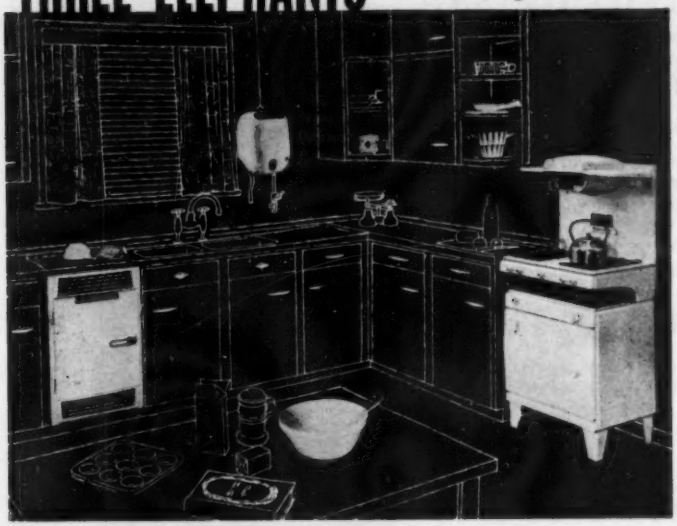

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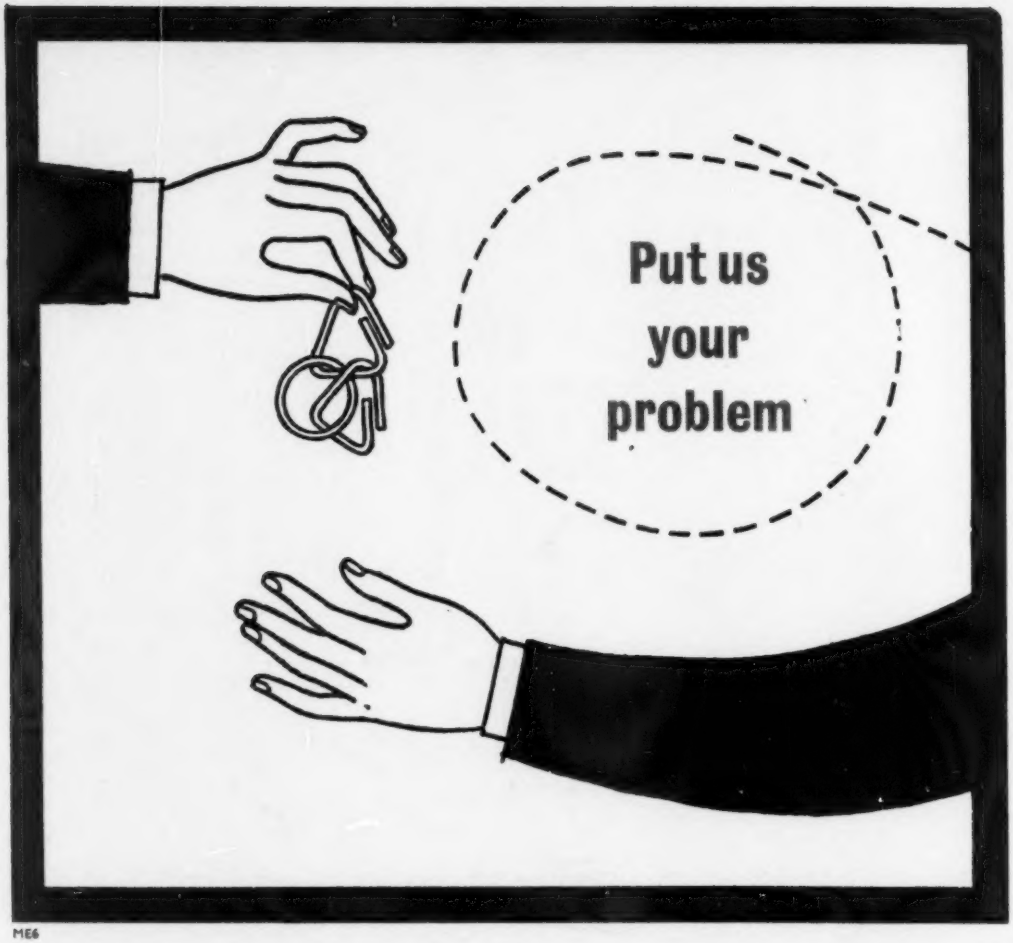

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